THE ASSOCIATION OF SEQUENCE OF HIRING PRACTICE AND BIOPHYSICAL COMPONENTS IN SCREENING PROBATIONARY FIREFIGHTERS

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ABSTRACT

Variation in hiring procedures occurs within fire service human resource departments. In this study, City 1 and City 2 applicants were required to pass their biophysical assessments prior to being hired as firefighters at the beginning and end of the screening process, respectively. City 1 applicants demonstrated significantly lower resting heart rate (RHR), resting diastolic blood pressure (RDBP), body fat% (BF) and higher z-scores for BF, trunk flexibility (TF) and overall clinical assessment (p<0.05). Regression analysis found that age and conducting the biophysical assessment at the end of the screening process explained poorer biophysical assessment results in BF% (R^2=21%), BF z-score (R^2=22%), TF z-score (R^2=10%) and overall clinical assessment z-score (R^2=7%). Each of RHR (OR=1.06, CI=1.01-1.10), RDBP (OR=1.05, CI=1.00-1.11) and BF% (OR=1.20, CI=1.07-1.37) increased the odds of being a City 2 firefighter (p<0.05). Biophysical screening at the end of the hiring process may result in the hiring of a less healthy firefighter.

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LIST OF ABBREVIATIONS

α	alpha
BUFF	Brock University Firefighting Screening Services
BPM	beats per minute
BF	body fat
BMI	body mass index
CPAT	Candidate Physical Ability Test
CRF	cardiorespiratory fitness
CVD	cardiovascular disease
FITCO	Fitness Test for Ontario Correctional Officer Applicants
METS	metabolic equivalents
RER	respiratory exchange ratio
RHR	resting heart rate
RSBP	resting systolic blood pressure
RDBP	resting diastolic blood pressure
TF	trunk flexibility
VO_2max	maximum volume of oxygen uptake
WHR	waist-to-hip ratio

CHAPTER 1- INTRODUCTION

1.1 Introduction

An organization's personnel selection involves identifying appropriate individuals for a position within an occupation from a pool of applicants (Chan, 2005). Although, selecting candidates who will successfully perform their employment duties is identified as a difficult task (Philbrick, Hass & Hahn, 1988). Pre-employment screening assessments are often included as a formal component of hiring practices to improve employee and organization fit, employee longevity (Hendrick & Raspiller, 2011) and assist with ensuring no major risks that may affect the person, the job, coworkers or third parties are evident (Whitaker & Aw, 1995). The focus of screening assessments commonly include the candidate's knowledge, skills, abilities or other elements that may predict one's capacity to successfully complete the job or additional work related factors such as job satisfaction or commitment (Chan, 2005).

Literature exploring hiring practices and pre-assessment of applicants has investigated the effectiveness of pre-screening methods on employee retention (Hendrick & Raspiller, 2011), turnover, accidents and absenteeism (Borofsky & Smith, 1993; Borofsky, Wagner & Turner, 1995), person-organization fit (Chan, 2005; Khalid, Ahyat & Bustaman, 2012) and work related-injuries (Campion, 1983; Harbin & Olson, 2005; Jackson, 1994; Rayson, 2000) as employers seek to hire individuals demonstrating skills and values to excel at the job. Hendrick and Raspiller (2011) propose that implementation of pre-employment assessment is a worthwhile step in organizational hiring practices to improve employee/employer fit, as matching an individual to an occupation must take into consideration not only the job, but also the environment in which one is required to function (Chan, 2005).

Hiring the wrong employee has been estimated to occur in 86% of hiring processes that rely solely on interviews and therefore it is recommended to include a second predictor in addition to the interview during the selection process. Therefore, it is recommended to include a second predictor in addition to the interview to decrease hiring error (Hunter & Hunter, 1984).

In relation to physically demanding occupations involving public safety, such as a firefighter, it has become common practice to institute an occupational assessment known as a Job Specific Physical Fitness Protocol or physical abilities test as a Bona Fide Occupational Requirement. Bona Fide Occupational Requirements are developed and implemented during pre-screening of potential employees as the safety of one self, coworkers and the public is reliant on the professional's ability to execute the essential demands of the job (Gumieniak, Jamnik & Gledhill, 2011). In addition, clinical health and fitness assessments are commonly performed during the screening of potential candidates to measure health related components of fitness, which are also found to be correlated to the execution of on-the-job tasks.

The relationships between fitness components and performance of physical abilities tests and occupational tasks for firefighters have been investigated to determine the essential physical qualities that are vital for the job. Specifically, both aerobic (Sheaff, Bennett, Hanson, Kim, Hsu, Shim, Edwards & Hurley, 2010; Williford, Duey, Olson, Howard & Wang, 1999; Williams-Bell, Villar, Sharratt & Hughson, 2009) and anaerobic systems (Rhea, Alvar & Gray, 2004; Sheaff et al., 2010;; Williams-Bell et al., 2009), muscular qualities (Michaelides, Parpa, Thompson & Brown, 2008; Michaelides, Parpa, Henry, Thompson & Brown et al., 2011; Rhea et al., 2004; Sheaff et al., 2010; Williford et al., 1999; Williams-Bell et al., 2009), body fat percentage (Michaelides et al., 2008; Michaelides et al., 2011; Williford et al., 1999) and flexibility (Michaelides et al., 2008; Williford et al., 1999) are all reported to correlate to a candidate's competency to complete a firefighter occupational assessment in its entirety or specific firefighting tasks within the appraisal.

In the area of clinical health and fitness screening, researchers have monitored the physiological responses of individuals while performing simulated firefighting tasks over the past two decades to assist with establishing the essential minimum standards for pre-screening assessments (Dreger & Petersen, 2007; Elsner & Kolkhorst, 2008; Gledhill & Jamnik, 1992a; Holmer & Gavhed, 2007; Romet & Frim, 1987; Von Heimburg, Rasmussen & Medbo, 2006; Williams-Bell et al., 2009). These results support the need for clinical health and fitness assessments and corresponding cut-off values. A cut-off value is defined as the test score an applicant must obtain in order to pass a specific assessment and be considered for a job. These scores are determined based on the desired work productivity, the safety of the worker and also level of adverse impact (Jackson, 1994).

While biophysical screening of probationary firefighter candidates is relatively standardized, the process of where in the hiring algorithm this screening occurs has been seen to vary among fire departments across Canada. Some include the biophysical assessment during phase one in the hiring process as a means of pre-employment screening prior to application for a position. In this case, only individuals who successfully pass the biophysical components are considered for employment application through additional administrative evaluations such as review of resume and personal interview. Conversely, other fire departments prefer to implement biophysical assessments later in the hiring process following the administrative evaluations which first narrow the candidate pool.

Similar variations in the sequencing of screening are also seen in physically demanding occupations such as policing and correctional workers. In Ontario, the physical ability test for policing takes place during phase one of screening, along with an analytical and English writing test (Applicant Testing Services, 2013). These assessments must be completed prior to phase II, which includes a behavioural analysis and a vision and hearing test. Once the candidate successfully completes phase I and II, the individual will receive a certificate of results and may apply to police services in Ontario (Applicant Testing Services, 2013).

Additionally, recent revision in hiring of correctional officers in Ontario has identified a physical abilities test, Fitness Test for Ontario Correctional Officer Applicants (FITCO), as part of the hiring process in 2013. The FITCO is included after the aptitude, cognitive and behavioural assessments and prior to the interview in the hiring process of correctional workers (Ontario Ministry of Community Safety and Correctional Services, 2013).

Although, the biophysical assessment is common in organizational hiring practices for occupations related to public safety, the order in which this component is administered in the hiring algorithm has yet to be investigated with respect to applicant outcome scores. As the variance in placement of clinical health and fitness and occupational assessments has yet to be explored, it is unknown whether or not varying the sequencing of physical pre-screening will influence a candidate's biophysical outcomes by revealing a more or less physically capable applicant. Due to the high demands of the firefighting profession, if varying physical capabilities are demonstrated by the applicants as a result of pre-employment hiring practice sequence, it may be of interest to fire services or additional physically demanding occupations. This information will provide a greater understanding of the importance of the order of employee screening to ensure fire services are hiring the most appropriate and capable individuals. The biophysical profile of a firefighter is essential in the pre-employment screening process as the safety of the public relies on these first responders.

1.2 Objective

The objective of this study was to examine the association of the sequencing of hiring practices and biophysical components in screening probationary firefighters.

1.3 Hypothesis

It was hypothesized that fire services implementing employee screening prior to biophysical testing of probationary firefighters will reveal candidates with lower biophysical and health assessment results.

CHAPTER 2 – REVIEW OF LITERATURE

2.1 Hiring practices and pre-employment screening

An organization's selection of employees is one of the most important decisions made in the workplace. Consequently, to ensure the best suited candidate is selected for a job, intrinsic differences in relation to abilities and skills should be measured and evaluated (Ajila & Okafor, 2012). In the last thirty years, a greater focus was placed on improved employee selection methods as organization's considered their screening strategies on employee selection and individual outcomes such as productivity and efficiency. As companies investigated alternative evaluations to examine a candidate's skill set, it was concluded the odds of hiring the right employee could be improved through the incorporation of non-traditional hiring processes (Hendrick & Raspiller, 2011).

Philbrick et al., (1988) outline three predominant reasons an increased importance has been place on screening measures in today's market. First, employers intend to pursue the most qualified and best performing applicant. Second, organizations seek to prevent or minimize losses as a result of a non-productive employee. Third, due to the increasing difficulty in terminating a worker, employers aim to secure the most suited applicant to the position. Finally, Jackson (1994) summarizes pre-employment screening methods may also minimize threat of litigation for discriminatory hiring practices and decrease musculoskeletal injuries.

Employers have several methods of assessing potential employees from applicant pools and there has been a rapid rise in standardized tests. The development of such tests evolved from the discipline of psychology and has further transpired into other areas, such as physical evaluation, as it is known that individuals displaying certain characteristics may be more or less suited for certain job requirements. The goal of pre-employment physical testing is to match a potential candidate's physiological capabilities to the demands of the occupation (Jackson, 1994).

A job analysis is an important component in the development of any pre-employment screening program as it provides an in depth understanding of the specific job and any behavioural requirements to create criteria and provide a framework for employee selection decisions (Cascio, 1998). For physically demanding occupations, this process must ensure that the identified physical duties and performance standards are adequate for the job to avoid being legally challenged (Jackson, 1994). This involves screening methods that demonstrate reliability and validity. A reliable assessment refers to a process that produces consistent results over time. Validity signifies how well a measure assesses what it is intended to measure and it's relativity to job performance (Philbrick et al., 1999).

Pre-employment screening methods are generally validated based on criterion-related validity, content validity or construct validity. Criterion validity refers to a study demonstrating the pre-employment test or chosen measures are a good predictor or correlated with elements of the job (Jackson, 1994). Test scores must specifically reveal a relationship to job performance (Cascio, 1998). Content validity involves the gathering of evidence to illustrate the pre-screening assessment is related to critical job duties (Jackson, 1994) and generally may include assessments such proficiency, knowledge or work sample tests (Cascio, 1998). Finally, construct validity establishes a specific construct or characteristic is required for successful job performance and the tool of assessment measures the identified construct (Jackson, 1994). This validation process identifies the meaning of the construct and differentiates and relates it to other constructs of variables (Cascio, 1998).

Chan (2005) reported in the past hiring personnel focused predominantly on comparing various methods of screening assessments such as personality or cognitive tests to predict optimal job performance. Performance is defined as the observable things people do that are relevant to the goals of the organization (Campbell, McHenry & Wise, 1990). Chan (2005) further states that much of the early research into hiring practices did not offer any real legitimate explanatory rationale of the assessment tools used as validation of the actual requirements of the job. More recently, it was suggested the use of a construct oriented approach better defines predictors of job execution and their relationship to the required job criteria (Chan, 2005).

For physically demanding occupations, such as firefighters, a greater shift has also lead to a content validity strategy using assessments involving fire suppression tasks and rescue techniques as opposed to criterion models of strength and endurance assessments (Henderson, Berry & Matic, 2007). Henderson and colleagues (2007) report validation studies on physical ability predictors for safety occupations in the literature are limited, although, tests are often completed in the form of a technical report to a government agency or private company (Jackson, 1994).

2.1.1. Screening methods and employee outcomes

The success of various pre-screening measures on employee selection is demonstrated in the literature. Pre-screening evaluations resulting in employee retention reported better results when implementing a pre-employment assessment tool such as a Work Key. Work Keys assessments have been designed for implementation in business and educational settings and rely primarily on content validation, although criterion and construct validity is also collected (ACT, n.d.). Results from Hendrick and Raspiller (2011) revealed 87% of the workers hired using the Work Key assessment tool within 12 companies in the production, service and medical sectors and one government agency, retained their employment for a minimum of 12 months, compared to less than 80% of individuals hired without this assessment.

Borofsky and Smith (1993) found frequency of employee turnover, accidents and unauthorized absences were all significantly lower when a pre-employment screening inventory in the form of an Employee Reliability Inventory was implemented in a manufacturing company, compared to a group hired prior to the inclusion of the assessment in the hiring process. Confirmation of these findings was reported in a longitudinal study over a 3 year period for turnover and work related accidents in a hospitality setting. Over the three years, turn-over rate of employees was reduced by a total of 26.82% and overall accident rate decreased by 29.41%. After considering the costs of administering the screening inventories during the study period, a cost savings of approximately $2,280,000 over three years was calculated based on the decreased turnover and accident costs (Borofsky, Wagner & Turner, 1995). The results of these studies supported on going use of a pre-employment screening inventory.

Organizational fit screening refers to matching the candidate and the work environment including the job, the work group or the organization as a whole (Chan, 2005). Khalid et al. (2012) states person-organization fit is related to organizational decisions such as acquisition, deployment and retention. Furthermore, successful organizations are found to employ individuals with the ability to adopt and adapt to areas such as organizational culture and working conditions. The predictive validity of pre-assessments is found to be dependent on the nature of the person, the environment and the criterion constructs (Chan, 2005). Criterion construct research may include complementary fit, the match between the needs or capabilities of the person and the associated environment, or supplementary fit which involves similar values beliefs or characteristics of the person and working environment. Therefore, the relationship between the predictors, as well as positives and negatives of organization fit and misfit are also important to consider (Chan, 2005).

Rayson (2000) believes screening methods ensuring individuals are fit for work, through the process of matching physical capabilities to job requirements and promoting fitness for life through health related physical activities are underutilized strategies for predicting decreases in absences and ill health retirements. Chaffin (1974) reported strength is related to injury rate and individuals are at an increased risk of experiencing an injury when job requirements exceeded individual capacity. Specifically, it is reported mean incident and severity rates of back injury may increase by a ratio of 3:1. Therefore, to protect individuals from low back injury, strength testing during pre-screening of employees may be a practical alternative (Chaffin, Herrin & Keyserling, 1978).

In general, injuries are more likely to occur in occupations that require physical strength beyond the capability an employee is able to demonstrate (Campion, 1983). Harbin and Olsen (2005) conducted a two part study to first investigate if physical capacity, determined through a functional capacity evaluation, can estimate injury incidence in a food production plant, and secondly to determine the effectiveness of a functional capacity evaluation when applied post-offer and pre-placement of employees seeking a position within an electrical equipment manufacturer.

Researchers reported a decrease in overall injury incidence through implementation of a functional capacity evaluation matching essential job functions. Specifically in relation to low back injuries, injury rates were 33% in individuals who did not have the physical capability to perform job functions compared to 3% in workers who did (Harbin & Olsen, 2005). Although, researchers emphasize a strength assessment cannot be used as a sole predictor of work related injury as assessments must represent actual physical requirements related to job specific duties. This study further revealed a decrease in lost days of work supporting the importance of such an evaluation as a cost-savings preventative program.

Another pilot program implementing a pre-employment physical exam for highway maintenance workers and supervisors revealed a gross financial savings of $358,000 annually based solely on workers compensation claims for back injuries, which accounted for 25% of claims

(Lukes & Brater, 1991). Snook (1991) suggests it is difficult to prevent low back injuries when the cause of the incidence is unknown, however, reducing the possibility of an occurrence is a proactive option. Decreasing risk may be addressed by reducing the probability of the initial event or the length of the disability once occurred, as well as decreasing the risk of reoccurrence through options such as job redesign, job placement, and education. Though certain occupations, such as firefighting, where job redesign cannot be applied it is recommended to emphasize job placement through selection of employees. This may include assessments such as strength testing to confirm capabilities of applicants and potentially decrease incidence of low back disorders (Snook, 1991).

Brownlie and colleagues (1985) suggest there are many benefits of implementing pre-screening assessments related to physical, psychomotor and mental capabilities early in the employee selection of firefighters. Their study involved the design of an effective selection procedure for entry level firefighters focusing primarily on biophysical screening assessments. Candidates began with gross physical elimination assessments, such as aerobic fitness, dummy carry and ladder lift, followed by psychomotor, flexibility and strength testing, obstacle course and finally knowledge tests. Failure to complete a stage of the assessment protocol resulted in the applicant being eliminated from the hiring pool. Administration of these assessments was found to effectively narrow the applicant pool of firefighters to a group of capable candidates to proceed to the interview process.

Overall, pre-screening of employees to fit the needs of various occupations has consistently reported success in areas of employee turnover or retention, absenteeism, personal-organization fit and work related injuries. Each of these areas contributes to the global cost savings of an organization through enhanced productivity of the worker, reducing rehiring and retraining expenses or costs associated with injury such as lost days of work or workers compensation claims. Overall, the literature is in agreement that pre-employment assessments are important to include in the hiring practices of an organization.

2.1.2 Physical evaluation

Campion (1983) suggested a need existed for improved methods of selecting candidates for physical demanding jobs for three predominant reasons. First, a greater number of females sought employment in physical demanding fields and considerable differences existed between genders in relation to strength, body composition and maximum aerobic fitness. Second, physically unfit workers have a greater incidence of low back injuries.

Back problems are the most common contributor to a decrease in work capacity and reduced leisure time physical activity (Campion, 1983). Additionally, low back pain is one of the most common chronic conditions in Canada (Schultz & Kopec, 2003) and a frequent cause of disability in people under the age of 45 (Oldridge, & Stoll, 1997). The high cost associated with low back pain is a result of the number of people affected by a related disorder (Oldridge & Stoll, 1997) with a lifetime prevalence rate between 58-70% in industrial countries and a yearly prevalence between 15-37% (Simmonds & Derghazrian, 2009). Specifically, a study by Beaton, Murphy & Pike (1996) investigating physically demanding occupations found in a sample of 2000 firefighters and paramedics, almost 50% of participants indicated aches and pain made it difficult for them to complete their work and the back was the second most commonly reported site of pain, 74.9%, after the neck 76%.

Strength and endurance measures in relation to firefighting and rescue task simulations provide strong evidence that these muscular quality assessments are highly valid for screening firefighters (Henderson, 2010). A continuous series of tasks, a set of discrete individual task simulations, direct measurements of strength and endurance or a combination of these approaches all reveal strong validity. Although, Jackson (1994) reports the use of general fitness tests such as pull-ups or sit-ups are less likely to be legally supported as typical fitness assessments do not look like usual tasks performed on the job and therefore are more likely to be challenged in court.

Lastly, Campion (1983) identified a need for improved procedures of screening as methods using solely medical evaluations are inadequate for physically demanding occupations. In general, the overall goal of a health assessment is to reduce health related career outcomes and job related safety risks (De Kort & Van Dijk, 1997). Medical evaluations should not be relied upon if they are not relevant to fulfilment of the essential job functions (Pachman, 2009).

According to the International Labour Office (1998), a medical exam may serve five main purposes. First, to evaluate the effectiveness of control measures in the workplace, ii) to detect pre-clinical and clinical abnormalities at a point when intervention is beneficial to individuals' health, (iii) to prevent further deterioration in workers' health, (iv) to reinforce safe methods of work and of health maintenance and (v) to assess fitness for a particular type of work. Thus, the medical exam does not focus on a candidate's ability to perform actual occupational duties as found in a physical abilities test.

Pre-employment physical screening generally includes job sample or simulation tests, or occupational assessments, representing specific tasks required to complete the job identified through job analysis or evaluations involving motor ability and physical fitness (Jackson, 1994). Job simulation tests are crucial to include in the screening of applicants as they evaluate the individual on the execution of the critical physically demanding on-the-job tasks (Jamnick, Thomas, Burr & Gledhill, 2009). As work sample tests simulate occupation activities, they are more likely to have content validity and are commonly used to screen applicants such as firefighters or police officers. In relation to firefighters, tasks may include climbing a ladder, pushing and pulling a ceiling hook, dragging a mannequin or running up stairs while carrying a hose bundle (Jackson, 1994).

Therefore, it has become common practice in occupations related to the safety of the public that Job Specific Physical Fitness Protocols are determined as Bona Fide Occupational Requirements that follow legislation, court judgements and Human Rights Tribunal Decisions. Such practices are of high importance as the safety of others relies on the abilities of the worker to successfully perform the job which is heavily weighted on demonstrating the required physical capabilities (Gumieniak et al., 2011).

Clinical health and fitness assessments are also essential as they reveal information in relation to the health status of an individual. For example, higher levels of cardiorespiratory fitness (CRF) are associated with improvements in cardiovascular disease risk factors (Baur, Christophi, Antonios, Tsismenakis, Cook, & Kales, 2011) and decreased metabolic abnormalities in firefighters (Donovan, Nelson, Peel, Lipsey, Voyles & Israel, 2009). Furthermore, increased frequency of physical activity is associated with reduced total cholesterol, high density lipoprotein ratio, triglycerides and glucose (Durand, Tsismenakis, Jahnke, Baur, Christophi & Kales, 2011). Higher body mass index (BMI) is also related to significant decreases in cardiorespiratory fitness (Durand et al., 2011) and increased cardiovascular disease risk factors (Durand et al., 2011; Soteriades, Hauser, Kawachi, Liarokapis, Christiani, & Kales, 2005).

Furthermore, an inverse correlation is also reported between the incidence of back injuries and fitness level in firefighters whereby those individuals with greater fitness levels experience less severe injuries. Researchers further reported back injuries occurring in the physically fit firefighters, were less costly than those in less fit individuals (Cady, Bischoff, O'Connell, Thomas & Allan, 1979) and higher fitness levels are associated with decreased neck, back and shoulder pain (Beaton, Murphy, Salazar & Johnson, 2002).

Therefore, clinical health and fitness assessment results can provide insight into the overall health status or risks of individuals. This information is important when considering the long-term performance of the firefighter as individuals are identified with current health concerns that may be at risk for future adverse effects in relation to the job.

2.1.3 Candidate Physical Abilities Test

The Candidate Physical Ability Test (CPAT) is as a bona fide occupational test as per collaboration from the International Association of Fire Chiefs (IAFC) and the International Association of Firefighters (IAFF). The goal in the creation of the CPAT was to ensure individuals demonstrate the essential physical ability required to execute key tasks through a structured and consistent evaluation (International Association of Firefighters, 2012b). Many municipalities in Ontario require successful completion of the CPAT as part of the pre-employment screening process.

The development process of the CPAT included a technical committee reviewing job analyses, job task surveys, performance tests and job descriptions implemented by 10 fire service jurisdictions from Canada and the United States. Additionally, data collected on equipment and demographics contributed to investigation of thirty-one firefighting tasks. Firefighters from each of the ten departments completed questionnaires to validate the critical tasks and skills that firefighters must execute (International Association of Firefighters, 2012b). The results of these analyses produced the eight simulated firefighting tasks of the CPAT in 1999. A formal licensing policy of the abilities test ensures the assessment administrators are using the CPAT as intended, and in 2008, a second edition of the program was published (International Association of Firefighters, 2012a).

2.2 Components of fitness

Early research by Davis, Dotson & Santa Maria (1982) revealed that two functions, physical work capacity, influenced by average intra-task heart rate and five simulated firefighting tasks, along with resistance to fatigue supported by a simulated rescue and a chopping task were related to firefighter performance. Additionally, physical performance variables such as maximum heart rate, sit-ups, grip strength, age and submaximal oxygen pulse influenced factor one and lean body weight, maximal heart rate, treadmill grade, age and percent body fat (BF) best predicted resistance to fatigue. Since this early research, many researchers have focused on each component of fitness and their subsequent contributions to firefighting responsibilities.

2.2.1 Cardiorespiratory fitness

Studies concentrating solely on cardiorespiratory fitness requirements explore the necessary intensities at which firefighters must perform and therefore assist with establishing the ideal aerobic capacity for screening purposes. Various responses have been reported in relation to the work capacity requirements of firefighters. Researchers focusing on a candidate's energy requirements as measured by a percentage of VO_2max range from an average of 62% (Elsner & Kolkhorst, 2008), 73% (Williams-Bell et al., 2009) and 76% (Sothman, Saupe, Jasenof, Blaney, Fuhrman, Woulfe, Raven Pawelczyk, Dotson, Landy, Smith & Davis, 1990).

Earlier work by Davis and Dotson (1978) suggested firefighters may be required to work at intensities near 97% VO_2max to carry out job responsibilities in an emergency environment. This level of energy expenditure represented an effort 12 times the requirement at rest, 1 MET. Maximum heart rate responses have also included 183 ± 9 measured at the end of a simulated protocol (Elsner & Kolhorst, 2008), averages of 173bpm (Sothman et al., 1990) and 175bpm (Williford et al., 1999) during simulated firefighter suppression protocols and close to 90%

maximum heart rate at the end of the stair climb when performing the CPAT (Williams-Bell et al., 2009).

Elsner & Kolklorst (2008) discovered metabolic responses averaging 29.1ml.kg.min and a maximum of 45.9 ml.kg.min while completing a series of simulated firefighting tasks at a self-directed pace. Homer and Gavhed (2007) reported an average of 33.9.ml.kg.min during simulated firefighter tasks on the ground and a maximum aerobic capacity of 43.8ml.kg.min. An average response of 34.1ml.kg.min during a work related test circuit implemented by the Department of National Defense is documented (Dreger & Peterson's, 2007), 37-39ml.kg.min while performing the CPAT (Williams-Bell et al., 2009) and a peak response of 44ml.kg.min during a hospital rescue protocol (Von Heimburg et al., 2006).

Research has also investigated the association between higher aerobic capacity and the probability of successful firefighter suppression task completion. These findings reveal individuals with an aerobic capacity under 33.5ml.kg.min were less likely to complete the protocol and suggested a more desirable VO_2max may be 41ml.kg.min (Bilzon, Scarpello, Smith, Ravenhill & Rayson, 2001; Sothman et al., 1990).

On the other hand, Gledhill and Jamnick (1992b) advise a slightly higher requirement and advocate an acceptable aerobic capacity is no less than 45ml.kg.min. Although, recent research by Wynn and Hawdon (2012) argue a reduction from 45.ml.kg.min to 42ml.kg.min does not cause any adverse health or employment outcomes. Additional recommendations have included 4.0L/min, or 50ml.kg.min, as subjects performed a simulated rescue of hospital patients in 7 minutes or less (Von Heimburg et al., 2006). Overall, variation in these findings is dependent on many factors such as the method of assessment, the type of activity required, type of pacing, environmental factors and duration of the simulation (Dregar & Peterson, 2007). Although, a set standard for aerobic fitness in firefighters is not conclusive, researchers agree individuals seeking employment in this profession must be able to perform at high intensities and demonstrate above average levels of cardiorespiratory fitness.

2.2.2 Muscular strength and endurance

Several studies have also investigated the necessity of a firefighter candidate to exhibit an adequate amount of muscular strength and muscular endurance for successful job performance (Gledhill & Jamnick, 1992b; Michaelides et al., 2008; Michaelides et al., 2011; Rhea et al., 2004; Sheaff et al., 2010; Von Heimburg et. al., 2006; Williams-Bell et al., 2009; Williford et al., 1999). Gledhill and Jamnick (1992a) suggest muscular strength and endurance in both the upper and lower body are essential for many occupational tasks. These tasks may include: lifting heavy objects from the ground to relocate, lifting objects to and from the chest or shoulder height, holding for extended periods or repeatedly manipulating objects at the waist to shoulder height, pulling objects using the arms and dragging objects. Researchers state both muscular strength and endurance are assessed during the occupational abilities test, as the simulated tasks could not be successfully executed without an adequate amount of either. However, additional recommendations do include implementation of the 60 seconds sit-up protocol to measure muscular endurance as part of the clinical health and fitness assessment (Gledhill & Jamnick 1992b).

Williford et al. (1999) also support the necessity of muscular qualities by revealing correlations between various strength and endurance assessments such as grip strength, pull-ups, push-ups and sit-ups and fire suppression tasks. Rhea et al. (2004) conducted a similar analysis including a larger battery of fitness assessments including additional resistance rather than callisthenic exercises. Results supported Williford et al. (1999) for grip strength, though, sit-ups were not correlated with the 4 chosen firefighting tasks. Investigators also found alternative muscular assessments such as the bent-over row endurance, bench press strength and endurance, shoulder press endurance, bicep endurance and squat endurance, all of which produced significance. Overall, these correlations support the value of strength and endurance, predominantly in the upper body, for firefighter professionals.

More recently, Michaelides et al. (2008; 2011) confirmed the necessity of strength and endurance in the upper body for abilities test completion. Both studies found push-ups and 1-RM bench press results significantly contributed to successful firefighter ability test completion time. Sit-ups were also related to better a performance time as well as specific tasks such as the stair climb, rolled hose lift and move and charged hose advance. Additionally, isometric strength of the abdominals was correlated with overall performance of the abilities test as well as all six of the simulated firefighting tasks (Michaelides et al., 2011).

Muscular quality contribution to successful completion of the CPAT is also an area investigated in the literature (Sheaff et al., 2010; Williams-Bell et al., 2009). Williams-Bell and colleagues (2009) concluded both men and women who did not complete the CPAT displayed lower strength and endurance than individuals completing the circuit. Variables of assessment included the bench press and leg press to examine both, strength and endurance, as well as grip strength, shoulder press and bicep curls further determining strength contributions. Grip strength was the strongest muscular predictor of CPAT performance, with a modest predictive ability, when a backward stepwise multiple linear regression was applied.

Sheaff et al. (2010) grouped participants according to successful and unsuccessful CPAT performance according to pass or fail time requirements rather than simply completion of all tasks within a circuit. Results disclosed grip strength and upper body strength assessed through the chest press 1RM significantly relate to CPAT performance time, though not necessarily to a pass or fail on the test. This finding does not support the conclusions of Williams-Bell et al. (2009), however, it does confirm research suggesting upper body contributions are important for execution of firefighting tasks, but not necessarily to completion time of an occupational assessment.

2.2.3 Flexibility

Few studies have focused on the relationship between flexibility and fire suppression tasks, though, it is recommended to assess flexibility during the screening process of firefighter candidates. A common tool used to assess flexibility during fitness pre-screening is the sit and reach test, which examines hamstring and lower back range of motion (Michaelides et al., 2008; Williford et al., 1999).

Michaelides et al. (2008) reported flexibility of the low back and hamstrings contribute to the prediction of abilities test scores in firefighters. Comparatively, Williford et al., (1999) found that flexibility was only significant with particular tasks of fire suppression, such as the stair climb, and a correlation with total completion time of the tasks did not exist. Further research is required to conclude the effect of flexibility on fire suppression tasks and abilities test scores. Hilyer and colleagues (1990) examined the effect of a flexibility intervention on the incidence and severity of joint injuries among municipal firefighters. They concluded although, the incidence of injury was not found to be different between groups, the severity of the injuries in the intervention group resulted in a significant less amount of lost time and work related costs. Therefore, it is recommended that flexibility exercises are included as part of a workplace exercise program (Hilyer et al., 1990).

2.2.4 Anaerobic fitness

Anaerobic system contributions also play a strong role during simulated firefighting tasks. Specifically, a respiratory exchange ratio (RER) of 1.02 for men and 0.97 for women is reported during the CPAT (Williams-Bell et al., 2009), as well as RER values greater than 1.0 in both genders during a firefighter evaluation circuit (Harvey, Kraemer, Sharratt & Hughson, 2008). These high values suggest elevated anaerobic contributions during the included firefighting tasks, however, Williams-Bell et al. (2009), advised although anaerobic contributions were evident, they were not one of the best predictors of CPAT completion compared to other predictors included in their study.

Controversially, additional research focusing on anaerobic power assessed through a step test as well as a 400m sprint were both found to be significant in predicting abilities test performance (Michaelides et. al., 2011; Rhea et al., 2004). Furthermore, in relation to the CPAT, absolute and relative mean power and peak power during the Wingate anaerobic cycling test were higher in individuals who passed the CPAT in comparison to those who failed. Researchers reveal absolute VO_2max and anaerobic fatigue resistance could predict 82% of CPAT performance. While maximal aerobic capacity was still found to be the stronger predictor of the two, measures of anaerobic fitness specifically contributed to the prediction of individual tasks such as the hose drag, ladder raise and extension, forcible entry and search tasks (Sheaff et al., 2010).

Peak lactate levels of 13$\pm$3mmol/l are also documented during performance of a simulated hospital rescue, although as firefighting operations generally last more than 5-9 minutes, Von Heimburg et al. (2006) suggest anaerobic capacity may be of limited importance. Overall, most researchers agree anaerobic contributions are evident during firefighting tasks, however, a single test clearly evaluating anaerobic fitness has not been concluded (Michaelides et al., 2011).

2.2.5 Balance and posture

Many of the tasks and unpredictable work conditions a firefighter may face require a great amount of postural control and balance. Currently, a balance assessment does not exist as part of the pre-screening process of firefighters since certain tasks of abilities tests demand balance for successful completion (Gledhill and Jamnick 1992b). Punakallio, Lusa & Luukkonen (2004) investigated the predictive value of functional, postural and perceived balance in respect to work ability at baseline and follow-up in firefighters. Researchers concluded the best predictors of decreased work ability after four years were poor-to-moderate perceived balance, greater than one error in the functional balance test and high mean amplitude of postural sway with eyes closed.

Furthermore, Punakallio, Hirvoenen & Gronqvist (2005) explored slip and fall risk in walking experiments with firefighters while wearing protective equipment to determine if any associations existed between balance, muscular capacities and age with the risk of slipping. Results revealed those who experienced critical foot slides and an increased risk of falling performed significantly poorer in the dynamic stability test. These findings suggest this type of assessment is a potential evaluation tool to add to the pre-screening parameters of firefighters. Additional research is required to focus on the necessity of assessing balance specifically as part of the pre-screening process.

In relation to posture, fatigued individuals adopted greater spinal flexion and reduced abdominal muscle activation after participating in the fatigue tasks from the CPAT protocol. These two findings may contribute to compromised spinal stability and possible increase risk of injury to the lower back (Gregory, Narula, Howarth, Russell & Callaghan, 2008).

2.2.6 Body composition

The relationship between body composition and a firefighter's ability to perform simulated firefighting tasks has been highly explored (Davis et al., 1982, Michaelides et al., 2008; Michaelides et al., 2011; Williford et al., 1999). Research examining the correlations between body fat and abilities test completion found a significant inverse relationship between performance of 6 simulated firefighting tasks and body mass index or percent body fat (Michaelides et al., 2008; 2011). Williford et al. (1999) reported fat free weight as one of the most significant predictors of the physical performance assessment involving 4 firefighting tasks.

The concern over obesity in firefighters does not only influence performance, but also many other related health concerns. Davis and Dotson (1987) suggest increases in body fat over time play a large role in the decreases seen in firefighter performance. Excess BF is also associated with negative cardiovascular effects, impeded mobility, heat dissipation and the increased risk of orthopaedic issues. Much research has focused specifically on the link between obesity and high blood pressure (Donovan et al., 2009; Fahs, Smith, Horn, Agiolvasitis, Rossow, Echols, Heffernan, Fernhall, 2009; Kales, Polyhronopoulos, Aldrich, Leitao & Christiani, 1999; Soteriades et al., 2005; Yoo & Franke, 2009). High blood pressure is one of the most prevalent cardiovascular disease (CVD) risk factors in firefighters (Donovan et al., 2009).

Lower exercise tolerance is another health concern in relation to body composition and job performance (Baur et al., 2011; Donovan et al., 2009). Current career firefighters exhibiting a lower aerobic capacity had greater metabolic abnormalities (Donovan et al., 2009) and higher CRF has a strong association with improvements in CVD risk factors after adjusting for age and BMI

(Baur et al., 2011). Tsismenakis and colleagues (2009) also investigated exercise tolerance in relation to obesity and stated every one unit increase in BMI is associated with a 54% greater chance of not being able to achieve 12 METS.

Overall, Clark, Rene, Theurer & Marshall (2002) investigated the usefulness of BMI as a pre-screening tool for both general health and duty fitness status of firefighters. Significant correlations with BMI and systolic and diastolic blood pressure, VO_2max, METS and total cholesterol concluded BMI as a useful screening tool for health measures. Additionally, high BMI results may also assist with identification of those requiring fitness interventions as increased BMI is associated with decreased performance (Tsismenakis et al., 2009).

It is often suggested BMI may misclassify individuals with too high of muscle mass, however, Poston and colleagues (2011b) compared each type of body composition assessment and concluded misclassification of BMI rarely occurs. In fact, obesity was more prevalent when assessing candidates using body fat percentage analysis. As body composition has negative effects on both health and job performance, it is imperative to be included as a screening measure of firefighters.

2.2.7 Combination of fitness parameters

Some studies have examined multiple fitness parameters to determine the most significant combination of predictors for successful execution of simulated firefighting tasks or the CPAT (Michaelides et al., 2008; 2011; Sheaff et al., 2010; Williford et al., 1999; Williams-Bell et al., 2009). Sheaff et al. (2010) determined both absolute VO_2max and anaerobic fatigue resistance account for 82% of CPAT performance predictability. Williams-Bell et al. (2009) agree with the contributions of both aerobic and anaerobic systems, however, these researchers conclude VO_2max along with body mass and grip strength are responsible for more than 67% of the variance, although, high errors of estimation exceeding 75 seconds occurred in their study. Williford et al. (1999) further confirm contributions of CRF, but also add fat free weight and muscular strength to the equation to explain 53% of the variation in performing firefighting suppression tasks. Alone, CRF assessed through the 1.5 mile run and fat free weight accounted for 50%. This study involved all non-laboratory methods of assessment.

Although CRF was not evaluated, Michaelides et al., (2008) reported flexibility, percent body fat, muscular strength and endurance in upper body and lower body strength explained 55% of the variance in performance time. Furthermore, abdominal strength, power, push-ups, resting heart rate (RHR) and body composition accounted for 60% of successful performance in their later research (Michaelides et al., 2011). Both studies agree high levels of body composition and elevated resting heart rates were associated with poor test execution. Consistency concerning the best combination of predictors does not exist in the literature.

Overall, the literature has investigated the effectiveness of pre-screening potential employees to meet organizational outcomes, (Borofsky & Smith, 1993; Borofsky et al., 1995; Campion, 1983; Chaffin, 1978; Chan, 2005; Hendrick & Raspiller, 2011; Harbin & Olsen; 2005; Khalid et al., 2012; Lukes & Brater, 1991) as well as significant components of fitness a firefighter candidate must demonstrate prior to hire in order to execute occupational duties (Dreger & Peterson, 2007; Gledhill and Jamnick, 1992; Homer & Gavhed, 2007; Michaelides et al., 2008; 2011; Rhea et al., 2004; Sheaff et al., 2010; Von Heimburg et al., 2006; Williams-Bell et al., 2009; Williford et al., 1999). However, the literature currently has not investigated the ideal order in which clinical health and fitness and occupational screening is administered in the hiring algorithm and furthermore, if the sequencing of such evaluations influences biophysical components positively or negatively. Therefore, the significance of this research is to contribute to the literature on pre-screening of employees and hiring practices and secondly, to report if the sequencing of pre-screening evaluations is associated with biophysical components for physically demanding occupations.

CHAPTER 3 - METHODS

3.1 Research design

This study included a cross-sectional design and secondary data analysis from Brock University Firefighter Screening Services (BUFF) from 2008 to 2012. Results from both clinical health and fitness raw data and component scores and occupational assessment times of successful applicants hired from two large metropolitan fire services were analyzed.

City 1 includes biophysical pre-screening of applicants at BUFF during phase 1 of hiring. Therefore, only applicants who are successful at passing all BUFF components are eligible for application to the fire service. Due to this sequence of screening, a large number of applicants are assessed during phase one.

City 2 includes biophysical pre-screening of applicants at BUFF during phase II of hiring, after completion of written aptitude and knowledge tests, an application review and an interview. These processes are followed by a conditional offer of employment and the selected applicants are sent to BUFF for further screening in the form of biophysical components. The average number of applicants testing at BUFF per hire from City 2 is 30.

Applicants applying to City 1 are competing against a larger number of potential candidates as BUFF testing is performed as the initial screening tool compared to City 2. Furthermore, as City 2 first narrows their applicant pool through the interview process, selected applicants are aware if he or she is successful at clinical health and fitness and occupational assessments, they will proceed to the final phase of hiring involving a final medical and police check. Consequently, the City 2 selection process results in the selected applicants having a potential job offer pending BUFF results.

Results of City 1 and City 2 candidate scores will be analyzed to determine if the variation in the sequencing of clinical health and fitness and occupational assessments is associated with applicant biophysical scores. Research ethics board at Brock University (Appendix 1) provided ethics approval.

3.2 Participants

A sample of 134 male firefighter applicants was incorporated in this study. Participants from both fire service municipalities were selected based on being recent entry-level hires completing pre-employment biophysical screening at BUFF from 2008-2012. City 1 included 58 recent hires, and City 2 is comprised of 76 recent hires.

3.3 Procedures and measurements

Brock University Firefighting Screening Services provided six assessment components including: 1) medical exam, 2) clinical health and fitness assessment, 3) occupational assessment (CPAT), 4) acrophobia test, 5) treadwater and 6) psychological aptitude.

All entry-level firefighter candidates were required to schedule an appointment for testing at BUFF and advised to follow the below guidelines prior to attending his or her appointment:

- Do not exercise within 12 hours
- Do not consume any alcohol within 48 hours
- Do no consume any diuretic medications within 7 days
- Do not consume caffeine within 12 hours
- Empty your bladder within 30 minutes
- Do not consume any food or drink within 4 hours

The following section describes each assessment tool utilized during clinical health, fitness and occupational screening processes. All assessments were conducted by BUFF examiners whose credentials included graduate education. Furthermore, all BUFF examiners were required to complete proficiency training of each evaluation component to ensure reliability of measurements.

3.3.1 Screening

All applicants are required to complete a PAR-Q questionnaire or PARMED-X, where appropriate, to ensure the candidates can safely perform the required physical activities (Appendix 2, 3). Additionally, candidates signed a consent form that described the nature of the assessment items and outlined applicant responsibilities (Appendix 4). Both forms were completed prior to the candidate's assessment.

Resting heart rate measures were taken using a Timex heart rate monitor after the candidate had been seated for 5 minutes. Resting blood pressure was measured using a 108-500 Sprague Type stethoscope and sphygmomanometer. Resting heart rate must have been less than 100 beats per minute and resting blood pressure not greater than 144/94mmHg in order to participate in the clinical health assessment. The American Heart Association (2013) defines normal blood pressure as a resting systolic blood pressure (RSBP) less than 120mmHg and resting diastolic blood pressure (RDBP) less than 80mmHg. Pre-hypertensive classification includes RSBP ranging from 120-139mmHg and RDBP between 80-89mmHg. Hypertensive individuals demonstrate RSBP values of 140-159mmHg and RDBP 90-99mmHg.

3.3.2 Body composition

Subjects were instructed to remove their shoes and excessive clothing prior to taking height and weight measurements. Height and weight were measured on a Detecto mechanical scale and recorded to the nearest 0.5 cm and 0.1 kg. For the purposes of this study, height and weight values were used to calculate each candidate's BMI. The World Health Organization (2013) classifies individuals with a BMI of 18.5-24.9 to be within the normal range. Overweight is defined as a BMI of 25-29.9, Obesity Class I is between 30-34.9 and Obesity Class II includes BMI values of 35-39.9. Waist circumference was measured using the CSEP protocol, at the top of the iliac crest at the midline of the body and recorded to the nearest 0.5 cm (McGuire & Ross, 2008). Hips were measured at the maximum circumference and recorded to the nearest 0.5cm. These measurements were used to calculate the candidate's waist-to-hip ratio (WHR) and a score out of 5 assigned (Appendix 5).

Body fat percentage was assessed through bioelectrical impedance analysis using the Bodystat 1500. Subjects were required to remove their right shoe and sock and lie supine with the arms 30 degrees from the sides of the body and legs not touching. Any jewellery on the right side of the body was removed. Electrode sites were cleaned with alcohol and electrodes placed on the hands on an imaginary line bisecting the ulnar head and the first joint of the middle finger. The foot electrodes were placed on an imaginary line bisecting the medial malleolus and the base of the second toe (Faught, Hay, Cairney & Flouris, 2005). The candidate's body fat percentage was compared to normative data (Klentrou, Montelpare, & Faught, 2000) and a score out of 5 applied (See Appendix 5).

3.3.3 Maximal aerobic fitness

Maximal aerobic fitness was measured using a graded exercise test on a motor-driven Cybex, Body Guard or Star Trac treadmill using the Bruce protocol. This protocol is a continuous, multi-stage test that gradually increases speed and grade of the treadmill every 3 minutes (CSEP, 1996). The candidate wore a full face mask for the purpose of collecting gases throughout the test. The candidate continued until he achieved a perfect score, reaches volitional fatigue and voluntarily terminates the test or symptoms dictate that the test must be terminated. Heart rate is also recorded using a Timex heart rate monitor.

Breath by breath gas analysis was recorded using a Vacumed Vista Mini CPX metabolic cart and the candidate's relative VO_2max recorded in ml.kg.min. The candidate's score was compared to normative data relative to one's gender and age (CSEP, 1996) and a score based on a 10 point scale assigned (Appendix 5).

3.3.4 Muscular endurance

The 60 seconds sit-up test assesses muscular endurance of the torso region. Candidates are required to lie in a supine position while resting their head on the mat, arms folded across their chest and legs bent at the knees to a 90° angle. While a lab assessor anchors their feet, the candidate bends at their hips and moves from the down position to a full sit-up position performing at maximal rate. The total number of sit-ups completed in one minute is recorded and compared to normative data based on age and gender and a score on a 5 point scale is assigned (Appendix 5).

3.3.5 Trunk flexibility

This assessment examines flexibility primarily of the hamstrings and lower back. Candidates are required to remove their shoes and sit with legs fully extended and soles of their feet placed flat against the flexometer. The candidate places one hand on top of the other, flexes at the hip while knees and legs remain straight, and extends their arms as far as possible while pushing the measurement curser. The candidate is required to hold the position for 2 seconds and the maximum trunk flexion is recorded to the nearest 0.5cm. The trunk flexibility assessment is performed three times. Maximum length was compared to normative data based on age and gender (CSEP, 2004) and a score based on a 5 point scale is appointed (Appendix 5).

Upon completion of the biophysical health assessments, a total score is calculated. A score of at least 18/30 is required to receive a passing grade on the clinical assessment.

3.3.6 Candidate Physical Ability Test

The CPAT consists of eight events that candidates must perform in a continuous manner that best simulates a fire scene and allows for an 85 feet walk between each event. Two stopwatches are used to ensure scoring accuracy. During this test, applicants are required to wear a 50lb vest to simulate the weight of self-contained breathing apparatus and firefighter protective clothing. An additional 25lbs is added to the individual's shoulders using two 12.5lbs weights to simulate a high-rise pack for the stair climb event. Long pants, a hard hat with chin strap, work gloves and footwear with no open heel or toe must also be worn.

The CPAT is a pass/fail test based on a validated maximum total time of 10 minutes and 20 seconds. A failure is given if any of the events are not completed correctly, or if the time of 10 minutes and 20 seconds is exceeded.

3.3.6.1 Stair climb

The first event, the stair climb, uses a step treadmill stair climbing machine. The machine is positioned with one side up against a wall and an elevated proctor platform on the side opposite the wall. A single handrail on the wall side is available to grasp while mounting and dismounting the step treadmill. This event is designed to simulate the critical tasks of climbing stairs in full protective clothing while carrying a high-rise pack (hose bundle) and firefighter equipment. Prior to the initiation of the timed CPAT, there is a 20-second warm-up on the stepmill, at a set stepping rate of 50 steps per minute. There is no break in time between the warm-up period and the actual timing of the test. After the start signal, the candidate walks on the stepmill at a set stepping rate of 60 steps per minute for 3 minutes.

3.3.6.2 Hose drag

The second event, the hose drag, uses an uncharged fire hose with a hoseline nozzle. The hoseline is marked at 8 feet (2.24 m) past the coupling at the nozzle to indicate the maximum amount of hose permitted to drape across the shoulder or chest. The hoseline is also marked at 50 feet (15.24 m) past the coupling at the nozzle to indicate the amount of hoseline that must be pulled into a marked boundary box before completing the test. This event is designed to simulate the critical tasks of dragging an uncharged hoseline from the fire apparatus to the fire occupancy and pulling an uncharged hoseline around obstacles while remaining stationary.

The candidate must grasp a hoseline nozzle attached to 200 feet (60 m) of 1 3/4-inch (44-mm) hose and place the hoseline over the shoulder or across the chest, not exceeding the 8-foot (2.24-m) mark. The applicant is permitted to run during the hose drag. The hose is dragged 75 feet (22.86 m) to a pre-positioned drum, a 90° turn around the drum is made, and the candidate continues an additional 25 feet (7.62 m). The candidate then stops within the marked 5 foot x 7 foot (1.52 m x 2.13 m) box, drops to at least one knee and pulls the hoseline until the hoseline's 50-foot (15.24-m) mark crosses the finish line. During the hose pull, at least one knee must remain in contact with the ground and knee(s) must remain within the marked boundary lines.

3.3.6.3 Equipment carry

The equipment carry, uses two saws and a tool cabinet replicating a storage cabinet on a fire truck. It is designed to simulate the critical tasks of removing power tools from a fire apparatus, carrying them to the emergency scene and returning the equipment to the fire apparatus.

Two saws are removed from the tool cabinet, one at a time, and placed on the ground. He or she then picks up both saws, one in each hand, and carries them while walking 75 feet (22.86 m) around the drum, and back to the starting point. Upon return to the tool cabinet, the saws are placed on the ground, and then picked up one at a time, and replaced in the designated space in the cabinet. The candidate then continues to the next event.

3.3.6.4 Ladder raise and extension

The ladder raise and extension uses two 24-foot (7.32-m) fire department ladders to simulate the critical tasks of placing a ground ladder at a fire structure and extending the ladder to the roof or window. The candidate must walk to the top rung of the 24-foot (7.32-m) aluminum extension ladder, lift the unhinged end from the ground, and walk it up until it is stationary against the wall. This must be done in a hand over hand fashion, using each rung until the ladder is stationary against the wall. The ladder rails cannot be used to raise the ladder.

The candidate then immediately proceeds to the pre-positioned and secured 24-foot (7.32-m) aluminum extension ladder, stands with both feet within the marked box of 36 inches x 36 inches (91.44 cm x 91.44 cm), and extends the fly section hand over hand until it hits the stop. Then, he or she lowers the fly section hand over hand in a controlled fashion to the starting position.

3.3.6.5 Forcible entry

This event uses a mechanized device located 39 inches (1 m) off the ground that measures cumulative force and a 10-pound (4.54-kg) sledgehammer. It is designed to simulate the critical tasks of using force to open a locked door or to breach a wall. A 10-pound (4.54-kg) sledgehammer is used to strike the measuring device in the target area until the buzzer is activated. During this event, the feet remain outside the toe-box at all times. After the buzzer activates, the sledgehammer is placed on the ground.

3.3.6.6 Search

This event uses an enclosed search maze that has obstacles and narrowed spaces to simulate the critical task of searching for a fire victim with limited visibility in an unpredictable area. The candidate must crawl through a tunnel maze that is approximately 3 feet (91.44 cm) high, 4 feet (121.92 cm) wide and 64 feet (19.51 m) in length with two 90° turns. At a number of locations in the tunnel, the applicant must navigate around, over and under obstacles. In addition, at two locations, the candidate must crawl through a narrowed space where the dimensions of the tunnel are reduced. Movement is monitored through the maze. If for any reason, the applicant chooses to end the event, he or she may call out or rap sharply on the wall or ceiling to be assisted out of the maze. Upon exit from the maze, the event is concluded.

3.3.6.7 Rescue

This event uses a weighted mannequin equipped with a harness with shoulder handles to simulate the critical task of removing a victim or injured partner from a fire scene. A 165-pound (74.84-kg) mannequin is grasped by the handle(s) on the shoulder(s) of the harness using one or both handles. The mannequin is dragged 35 feet (10.67 m) to a pre-positioned drum, a 180° turn is made around the drum, and the candidate continues an additional 35 feet (10.67 m) to the finish line. The candidate may not grasp or rest on the drum, but it is permissible for the mannequin to touch the drum, to drop and release the mannequin and/or adjust grip. The entire mannequin must be dragged until it crosses the marked finish line.

3.6.6.8 Ceiling breach and pull

This event uses a mechanized device that measures overhead push and pull forces and a pike pole. The pike pole is a commonly used piece of equipment that consists of a 6-foot long pole with a hook and point attached to one end. This event is designed to simulate the critical task of breaching and pulling down a ceiling to check for fire extension. The pike pole is removed from the bracket, stand within the boundary established by the equipment frame, and place the tip of the pole on the painted area of the hinged door in the ceiling. Then, the candidate fully pushes up the 60-pound hinged door in the ceiling with the pike pole three times, hooks the pike pole to the 80-pound ceiling device and pulls the pole down five times. Each set consists of three pushes and five pulls. The set is repeated four times.

The applicant is permitted to stop and, if needed, adjust grip. Releasing the grip or allowing the pike pole handle to slip, without the pike pole falling to the ground, does not result in a warning or constitute a failure, the candidate may re-establish his or her grip and resume the event. If a repetition is not completed successfully, the assessor calls out "miss" and the candidate must push or pull the apparatus again to complete the repetition. This event and the total test time ends when the final pull stroke repetition is completed as indicated by the assessor who calls out "time."

3.4 Statistical analyses

All statistical analyses were performed using SPSS, V.20 (IBM Corporation, 2010). Descriptive statistics were calculated for mean and standard deviation for subject age, height, weight, resting heart rate, body mass index, resting systolic blood pressure, resting diastolic blood pressure and all biophysical health and fitness and occupational raw and component scores to compare sample characteristics between City 1 and City 2. Health risk classifications according to BMI and blood pressure categories were also examined. Z-scores were calculated to standardize the scores for all categorical variables representing BUFF component scores based on candidate age. All z-scores were summed to create a sum of z-scores variable. Z-scores for each age category within the component scores were also created. A t-test was used to determine significant differences between City 1 and City 2 firefighter characteristics and all continuous variables. Chi square analysis was conducted to determine significant difference for categorical variables.

Linear regression analysis was conducted to establish if differences in the sequence of hiring practice within the two cities was associated with clinical health and fitness or occupational assessment results. Age was considered a confounding variable and was controlled for in the linear regression analysis. Unadjusted R^2 values were examined to identify the explained variance of the predictor variables and standardized β-weights were assessed to report contributions of the independent variables. Age adjusted means were also tested to account for the impact of age on the regression model. Pairwise comparisons verified if significant differences remained in a predictor variable after adjusting for age. Logistic regression was conducted to calculate the odds of each variable predicting a candidate being in City 1 or City 2. Level of significance was established at two-tailed $\alpha=0.05$.

CHAPTER 4 – RESULTS

4.1 Sample characteristics

This study examined firefighter applicants applying to two different cities implementing biophysical health, fitness and occupational assessments at different stages in the hiring process. A sample of 134 firefighter applicants, including 58 from City 1 and 76 from City 2, was included in this study. Table 4.1 presents the subject descriptive characteristics for each city relative to age, height, weight, resting heart rate, resting systolic and diastolic blood pressures and BMI.

Overall, variables revealed normal distribution through examination of histograms, except resting systolic and diastolic blood pressures for City 2 which demonstrated kurtosis. Equal variance between groups also did not exist for resting diastolic blood pressure. City 2 applicants were older (30.54 vs. 27.33, p=0.001) and demonstrated significantly higher resting heart rates (75.33 vs. 70.59, p=0.007) and resting diastolic blood pressure (77.83 vs. 72.71, p=0.001). There were no significant differences in height, weight, and resting systolic blood pressure between city subjects (p>0.05). BMI approached significance (p=0.07). As normal distribution was not found in all variables, non-parametric analyses were conducted and results were confirmed.

Although health risk classifications for BMI and blood pressure were not statistically significant, results revealed 35% of firefighters from City 1 had demonstrated a normal BMI compared to 30% of firefighters in City 2. Sixty-four percent of City 1 applicants were overweight according to their BMI, while 2% were considered obese compared to 55% and 13% respectively in City 2. Furthermore, City 2 also reported that 1% of their applicants were in the class II obese category. Seventeen percent of City 1 candidates had normal blood pressure compared to 12% of subjects from City 2. Seventy-two candidates from City 1 were pre-hypertensive and 10%

hypertensive. Although fewer City 2 applicants (68%) were pre-hypertensive, a greater number, 20%, were identified as hypertensive.

Table 4.1 City 1 and City 2 firefighter candidate characteristics

Variable (mean, [SD])	City 1 n=58	City 2 n=76
Age (years)	27.33 [4.98]	30.54 [5.73]†
Height (cm)	179.97 [6.67]	179.85 [5.86]
Weight (kg)	82.88 [9.50]	85.46 [10.97]
RHR (bpm)	70.59 [8.64]	75.33 [10.75]*
RSBP (mmHg)	125.31[9.84]	127.14[9.09]
RDBP (mmHg)	72.71[10.23]	77.83[7.71]†
BMI (kg/m^2)	25.55[2.18]	26.39[3.02]
Variable (%)		
Normal BP	17%	12%
Pre-hypertensive	72%	68%
Hypertensive	10%	20%
Normal BMI	35%	30%
Overweight	64%	55%
Obesity Class I	2%	13%
Obesity Class II	0	1%

Note: † = $p \leq 0.001$; * = $p < 0.05$
RHR = Resting Heart Rate; BP = Blood Pressure; RSBP = Resting Systolic Blood Pressure, RDBP = Resting Diastolic Blood Pressure; BMI = Body Mass Index

4.2 Biophysical fitness and health scores

Table 4.2 presents the clinical health and fitness assessment raw and component scores as well as the CPAT occupational assessment for City 1 and 2. Significant differences in clinical health and fitness assessments were present in body fat percentage, 60 second sit-up raw scores and sit-up and body fat component scores for ages 30-39. Body fat percentage raw score was higher in City

2 (18.39 vs. 15.61, $p<0.001$), and the corresponding component scores were lower for the 30-39 age group (2.09 vs. 2.68, $p=0.05$). City 2 subjects completed significantly fewer sit-ups than City 1 subjects (47.55 vs. 50.48, $p=0.03$) and the 60 second sit-up component score was also significantly higher in the City 1 subjects age 30-39 years (2.68 vs. 2.09, $p=0.03$). There were no significant differences between cities with respect to waist-to-hip ratio, trunk flexibility and VO_2 max raw and component scores or CPAT time ($p>0.05$). The examination of histograms revealed body fat percentage, trunk flexibility and VO_2max raw score demonstrated kurtosis and waist-to-hip-ratio and CPAT time had positive skewness in City 1. City 2 descriptive statistics presented kurtosis in VO_2max raw score. Equal variance between groups was not found in VO_2max raw score. As normal distribution was not found in all variables, non-parametric analysis confirmed similar results. Overall, results revealed City 2 performed poorer on all BUFF components except for VO_2 max and WHR component scores for those ages 20-29 years.

Mean z-scores for each BUFF component variable are presented in Table 4.3. Conversion of the component scores to z-scores found body fat percentage to remain significantly different between groups (.3509825 vs. -.2678551, $p<0.001$) as well as the sum of z-scores for all BUFF components (0.6628 vs. -0.5058, $p=0.008$). Sit-up component score was no longer significant when converted to a z-score. Overall, City 1 z-scores were above the mean for all BUFF components and City 2 were below the mean.

Z-scores for each age category are presented in Table 4.4. Examining z-scores for the 20-29 age group revealed body fat (.2508690 vs. -.2508690, $p=0.03$) and trunk flexibility (.2212332 vs. -2212332, $p=0.05$) scores were significantly different between City 1 and City 2. Furthermore, for the 30-39 age group sum of z-scores for City 1 (.3739336 vs. -.2089629, $p=0.04$) was significantly higher and body fat z-score approached significant (.3363922 vs. -.1879839, $p=0.07$).

Overall, City 1 demonstrated z-scores above the mean in all age groups except WHR and VO_2max for the 20-29 age group.

Table 4.2 Clinical assessment raw and component scores (mean [SD])

	City 1 N=58	City 2 N=76
Waist-to-Hip Ratio	0.82 [0.04]	0.83 [0.04]
Waist-to-Hip Ratio Score		
20-29 years (n=38; n=38)	4.11 [.86]	4.29 [.80]
30-39 years (n=19; n=34)	3.95 [.85]	3.76 [.82]
40-49 years (n=1; n=4)	4 [0]	4 [.82]
Body Fat (%)	15.61 [4.08]	18.39 [3.99] †
Body Fat Score		
20-29 years (n=38; n=38)	3.29 [.98]	2.74 [1.16]
30-39 years (n=19; n=34)	2.68 [1.38]	2.09 [.93]*
40-49 years (n=1; n=34)	3 [0]	1 [0]
VO_2 max (ml.kg.min)	52.53 [3.53]	51.67 [4.16]
VO_2 max Score		
20-29 years (n=38; n=38)	8.66 [1.98]	8.82 [1.74]
30-39 years (n=19; n=34)	9.21 [1.36]	8.79 [1.59]
40-49 years (n=1; n=4)	10 [0]	8.5 [1.73]
60 Second Sit-Up (#)	50.48 [6.90]	47.55 [8.12]*
60 Second Sit-Up Score		
20-29 years (n=38; n=38)	4.05 [.90]	3.92 [1.15]
30-39 years (n=19; n=34)	4.11 [1.10]	3.76 [.99]*
40-49 years (n=1; n=4)	5 [0]	3.5 [1.29]
Trunk Flexibility (cm)	38.79 [5.25]	37.21 [5.70]
Trunk Flexibility Score		
20-29 years (n=38; n=38)	4.29 [.93]	3.84 [1.05]
30-39 years (n=19; n=34)	4.58 [.61]	4.44 [.82]
40-49 years (n=1; n=4)	5 [0]	5 [0]
CPAT Time (sec)	526.74 [36.32]	533.46 [32.53]

Note: * = $p \leq 0.05$

Table 4.3 Mean z-scores for BUFF component scores

Variable	City 1 N=58	City 2 N=76
Z-score: Waist to Hip Ratio Score	.0082765	-.0063162
Z-score: Body Fat Score	.3509825	-.2678551†
Z-score: VO_2 max Score	.0241154	-.0184038
Z-score: Trunk Flexibility Score	.1379439	-.1052730
Z-score: Sit-up Score	.1414469	-.1079463
Z-score: Sum of BUFF Component Scores	.6628	-.5058*

Note: * = $p<0.05$; † = $p<0.001$

Table 4.4 Mean z-scores per age group for BUFF component scores

	City 1 n=58	City 2 n=76
Z-score: Waist-to-Hip Ratio Score		
20-29 years (n=38; n=38)	-.1105729	.1105729
30-39 years (n=19; n=34)	.1418774	-.0792844
40-49 years (n=1; n=4)	0	0
Z-score: Body Fat Score		
20-29 years (n=38; n=38)	.2508690	-.2508690*
30-39 years (n=19; n=34)	.3363922	-.1879839
40-49 years (n=1; n=34)	1.7888544	-.4472136
Z-score: VO_2 max Score		
20-29 years (n=38; n=38)	-.0426702	.0426702
30-39 years (n=19; n=34)	.1767100	-.0987497
40-49 years (n=1; n=4)	.7302967	-.2300895
Z-score: Sit-Up Score		
20-29 years (n=38; n=38)	.0641076	-.0641076
30-39 years (n=19; n=34)	.2118121	-.1183656
40-49 years (n=1; n=4)	.9203580	-.2300895
Z-score: Trunk Flexibility Score		
20-29 years (n=38; n=38)	.2212332	-.2212332*
30-39 years (n=19; n=34)	.1178513	-.0658581
40-49 years (n=1; n=4)	0	0
Z-score: Sum of BUFF Component Scores		
20-29 years (n=38; n=38)	.1412960	-.1412960
30-39 years (n=19; n=34)	.3739336	-.2089629*
40-49 years (n=1; n=4)	1.2977714	-.3244428

Note: * = $p \leq 0.05$

4.3 Regression analyses and estimated marginal means

Linear regression analysis was performed for all continuous and categorical variables (See Table 4.5). Non-significant models were found in WHR z-score, VO_2max z-score, sit-up z-score and trunk flexibility raw score. As work capacity is found to decrease with age (Fleg, Morrell, Bos, Brant, Talbot, Wright, Lakatta, 2005; Sheppard 1999), we controlled for age and city hiring practice was found to significantly predict resting heart rate, resting diastolic blood pressure, body fat percentage, body fat and trunk flexibility z-scores and sum of z-scores. Age was found to be the only significant contributor to resting systolic blood pressure and blood pressure categories, BMI and BMI classification, WHR, sit-up, VO_2max raw scores and CPAT time. Estimated marginal means confirmed significance in resting heart rate, resting diastolic blood pressure, body fat percentage, body fat and trunk flexibility z-score and sum of z-scores after adjusting for age (p<0.05). Overall, City 1 performed better on all variables after adjusting for age, except WHR z-score (See Table 4.6).

Age and hiring practice explain 6% of the variation in resting heart rate in firefighter subjects. The model was significant ($F_{(2, 131)}$=3.8, p<0.03) and standardized β-weights revealed city hiring practice to have a greater loading compared to age (β=0.23, t=2.54, p=0.01). In relation to resting diastolic blood pressure, the two predictor variables explained 16% of the variance in firefighter candidates and demonstrated a significant model ($F_{(2, 131)}$=12.31, p<0.001). City hiring practice was a significant contributor (β=0.19, t=2.28, p=0.02), however, age had a stronger impact (β=0.30, t=3.58, p<0.001).

Age and hiring practice explained 21% (R^2=0.21) of the variation in body fat percentage raw scores for firefighters. This model was significant ($F_{(2, 131)}$=17.19, p<0.001) and standardized β-weights revealed age to have greater loading compared to city hiring practice (β=0.33, t=4.11, p<0.001). The predictor variables also accounted for 22% (R^2=0.22) of the variance found in body fat z-scores between City 1 and 2. This model was significant ($F_{(2, 131)}$=18.05, p<0.001) and similar to body fat percentage results, age demonstrated a greater standardized β-weight compared to the city hiring practice predictor (β=-0.36, t=-4.5, p<0.001). Finally, 7% of the variance in the sum of BUFF component z-scores was explained by age and hiring practice (R^2=0.07). This model was significant ($F_{(2, 131)}$=4.88, p=0.009) and city hiring practice revealed a greater standardized β-weight=-0.19 (t=-2.1, p=0.04) compared to age.

Table 4.5 Regression of age and city hiring practice on health and fitness variables

Variable	R^2	Age	City 2
RHR	.06	.03 [.29]	.23 [2.54]*
RSBP	.07	.25 [2.88]*	.03 [.28]
RDBP	.16	.30 [3.58]†	.19 [2.28]*
Blood Pressure Category	.07	.23 [2.56]*	.07 [.80]
BMI	.08	.26 [2.92]*	.08 [.95]
BMI Category	.05	.18 [2.01]*	.10 [1.08]
Waist-to-Hip Ratio	.17	.41 [4.93]*	.01 [.09]
Z-score: Waist-to-Hip Ratio Score	.04	-.22 [-2.30]	.05 [.57]
Body Fat %	.21	.33 [4.10]†	.23 [2.84]*
Z-score: Body Fat Score	.22	-.36 [-4.50]†	-.21 [-2.55]*
VO_2 max	.43	-.67 [-9.77]†	.08 [1.12]
Z-score: VO_2 max Score	.001	-.02 [-.20]	-.02 [-.17]
60 Second Sit-Up	.12	-.31 [-3.57]†	-.10 [-1.19]
Z-score: Sit-Up Score	.02	-.07 [-.82]	-.10 [-1.14]
Trunk Flexibility	.03	.07 [.82]	-.16 [-1.81]
Z-score: Trunk Flexibility Score	.10	.31 [3.53]*	-.21 [-2.40]*
Z-score: Sum of BUFF Component Scores	.07	-.14 [-1.58]	-.19 [2.13]*
CPAT Time (sec)	.06	.23 [2.58]*	.03 [.37]

Standardized b-coefficients are reported with t value in parentheses
Note: * = p<0.05; † = p<0.001

Table 4.6 Age adjusted means

Variable	City 1 N=58	City 2 N=76
RHR	70.67	75.26*
RSBP	126.18	126.56
RDBP	73.60	77.15*
Blood Pressure Category	1.97	2.05
BMI	25.77	26.22
BMI Category	1.71	1.83
Waist to Hip Ratio	.82	.82
Z-score: Waist to Hip Ratio Score	-.06	.04
Body Fat%	16.07	18.04*
Z-score: Body Fat Score	.23	-.18*
VO_2max	52.32	51.68
Z-score: VO_2 max Score	.02	-.01
Sit-ups	49.72	48.14
Z-score: Sit-ups Score	.18	-.09
Trunk Flexibility	38.93	37.11
Z-score: Trunk Flexibility	.24	-.18*
Z-score: Sum of BUFF Component Scores	.55	-.43*
CPAT	529.27	531.52

Note: * = $p<0.05$

4.4 Logistic Regression

Logistic regression analysis discovered for every one unit increase in resting heart rate, candidates were 6% more likely to be in the City 2 hiring pool (OR 1.06, CI 95% 1.01-1.12, p=0.01*)* (Table 4.7). Similarly to RHR, every one unit increase in RDBP was associated with 5% greater odds (OR 1.05, CI 95% 1.00-1.11, p=0.04) of being in City 2. Compared to those with a normal BP, the odds of being in City 2 from the hypertensive category approached significance at 3.7 times greater odds

(OR 3.73, CI 95% .94-14.87, *p*=0.06). Furthermore, being in the pre-hypertensive category was also more likely for City 2 applicants, although it was not significant (OR 1.65, CI 95%, *p*=0.35).

Each unit increase in BF percentage was associated with a 20% increased odds of the candidate belonging to City 2 (OR 1.20, CI 95% 1.07-1.37, *p*=0.002*)*. Furthermore, compared to those with a normal BMI, the odds of being in City 2 from the obese category is 10.3 times higher among firefighters subjects (OR 10.3, CI 95% 1.20-88.33, *p*=0.03). Firefighters classified as "above average" for a BF component score were more likely to be in City 1 compared to those subjects with a "poor" classification (OR .20, CI 95% .07-.61, *p*=0.005). The odds of being classified as subjects in City 1 with "average" (OR .36, CI 95% .13-1.03, *p*=0.06) and "excellent" (OR .10, CI 95% .01-1.23 *p*=0.07) BF categories approached significance. Furthermore, although it was not significant, a body fat component score of "below average" increased the odds of being in City 2 by 54% (OR 1.54, CI 95% .43-5.56, *p*=0.51).

Table 4.7 Odds ratios of biophysical health and fitness variables on City 2

Variable	OR (95% CI)
Model 1	
Age	1.09 [1.01-1.18]*
RHR	1.06 [1.01-1.11]*
RSBP	.97 [.93-1.02]
RDBP	1.05 [1.00-1.11]*
BMI	1.12 [.96-1.30]
Model 2	
Blood Pressure Category	
Normal	1.00
Pre-hypertensive	1.65 [.57-4.74]
Hypertensive	3.73 [.94-14.87]
BMI Category	
Normal	1.00
Overweight	.86 [.39-1.85]
Obese	10.28 [1.20-88.33]*
Model 3	
Waist to Hip Ratio	.57 [0-217388.77]
Body Fat%	1.20 [1.07-1.36]*
VO_2max	1.02 [.91-1.5]
Sit-ups	.96 [.90-1.02]
Trunk Flexibility	.95 [.88-1.03]
Z-Score: Sum of BUFF Component Scores	1.07 [.83-1.04]
CPAT	1.00 [.99-1.02]
Model 4	
Body Fat Score	
Poor	1.00
Below Average	1.54 [.43-5.56]
Average	.36 [.13-1.03]
Above Average	.20 [.07-.61]*
Excellent	.10 [.00-1.25]
Z-score: Waist to Hip Ratio Score	1.22 [.81-1.82]
Z-score: VO_2max Score	.68 [.68-1.48]
Z-score: Sit-up Score	.90 [.60-1.35]
Z-score: Trunk Flexibility Score	.72 [.48-1.07]

Note: * = $p<0.05$

CHAPTER 5 – DISCUSSION

5.1 Biophysical scores and impact on health and performance

To our knowledge, this study was the first to examine differences that an employee hiring sequence can have on biophysical health and fitness assessment scores in firefighter applicants. The main finding was that age and hiring practice sequence explained the largest variance in differences found between the hiring sequence by two cities regarding resting diastolic blood pressure, body fat percentage, body fat z-score and flexibility z-score. Hiring practice sequence was only found to contribute to the variation in resting heart rate and sum of z-scores. Furthermore, a hiring sequence incorporating biophysical tests at the beginning of employee screening process revealed better performance of applicants on the majority of biophysical assessments for all age groups. Significant differences were found in clinical health and fitness assessments of BF%, BF and trunk flexibility z-score and sum of z-scores after adjusting for age.

It is also important to note pre-screening measures of resting heart rate and resting diastolic blood pressure were also significantly higher in firefighter applicants who underwent a biophysical assessment at the end of the screening process (City 2). These findings reflect a poorer health status of City 2 applicants as they demonstrated higher resting heart rate and diastolic blood pressure values. These biophysical health determinants are associated with increased risk for cardiovascular disease (Franklin, 2007; Kannel, Kannela, Paffenbarger & Cupples, 1987).

BUFF clinical health assessments and corresponding component scores represent typical health related measures and norms for the general population (CSEP, 1996; CSEP, 2004; Heyward, 2010; The Cooper Institute, 1993). It would be expected that firefighter candidates demonstrate superior performance on such assessments due the physical rigors of their job in addition to the responsibility for public safety. However, the results of this study suggest City 2 applicants demonstrate less favourable biophysical assessment results compared to City 1, which may impact the overall performance of new recruits early in their career as well as long-term health.

The significantly higher amount of body fat demonstrated by City 2 applicants is of concern due to the negative impact it has on general health. Individuals with excess amounts of fat are more likely to exhibit increased cardiovascular disease risk factors such as hypertension (Donovan et al., 2009; Fahs, Smith, Horn, Agiolvasitis, Rossow, Echols, Heffernan, Fernhall, 2009; Kales, Polyhronopoulos, Aldrich, Leitao & Christiani, 1999; Soteriades et al., 2005; Yoo & Frank, 2009), decreased high density lipoproteins (Soteriades et al., 2005; Tsismenakis et al., 2009) and chronic conditions such as type II diabetes, osteoarthritis, (Mokdad, Ford, Bowman, Dietz, Vinicor, Bales, Marks, 2003; Must, Spadano, Coakley, Field, Colditz & Dietz, 1999) and asthma (Mokdad et al., 2003). Furthermore, individuals with an increased amount of body fat report a reduced exercise tolerance (Tsismenakis et al., 2009), which may impair firefighter performance during and after the most strenuous tasks.

Although a firefighter's health may be impacted by the development of any of the aforementioned chronic conditions, CVD is of primary concern in the fire service as sudden cardiac death is the number one cause of on-duty deaths (Fahy, Leblanc & Molis, 2007). Research by Kales and colleagues (2002, 2007) reported that most on-duty fatalities are due to cardiovascular events in firefighters with a significantly higher prevalence of cardiovascular risk factors and during performance of strenuous firefighting tasks. The elevation of obesity and CVD risk factors over the career of firefighters is concerning with increases in fat mass, blood cholesterol (Davis et al., 2002) and blood pressure (Davis et al., 2002; Soteriades et al., 2005). Obese firefighters also report greater weight gain and hypertension over five years compared to those of normal weight (Soteriades et al., 2005). Although increases in CVD risk factors are generally associated with age, obese firefighters exhibit a greater number of risk factors compared to colleagues of normal weight (Soteriades et al., 2005). Similarly, relative body fat was found to predict elevated blood pressure and TC/HDL ratio in firefighters (Davis et al., 2002).

High blood pressure is the most common risk factor in firefighters with adverse events being 2 to 3 times more likely to occur in those with stage II hypertension (Donovan et al., 2009; Kales et al., 2002). Though our study did not find statistical significance in blood pressure classification, a greater percentage of City 2 candidates were identified as hypertensive as well as demonstrating a significantly higher resting diastolic blood pressure. Quite possibly elevations in blood pressure did not have sufficient time to produce the physical manifestations expected of hypertension in City 2 subjects despite the older age of these firefighter applicants. Overall our findings suggest the significantly higher amount of body fat found in City 2 candidates places them at a greater risk for CVD and potentially on duty fatality. Since early life onset of obesity is identified as a strong predictor of obesity in adulthood (Guo, Chumlea & Roche, 2002; Whitaker, Wright, Pepe, Seidel & Dietz, 1997), it is advantageous to hire firefighter applicants with no or lower risk as seen in City 1 applicants to limit the impact of these consequences on health and vocational performance over both short and long term.

The higher amount of body fat demonstrated in City 2 applicants is also a concern due to the negative effects related to job performance. Obesity in firefighters is reported to predict job disability as every one unit increase in BMI was found to increase the risk of job disability by 5% (Soteriades et al., 2008) and the odds of filing a workers compensation claim are nearly 3 times greater for firefighters with a BMI greater than 30 (Kuehl, Kisbu-Sakarya, Elliot, Moe, DeFrancesco, MacKinnon, Lockhart, Goldberg & Kuehl, 2012). Poston and colleagues (2011b) also found firefighters considered as class II and III obese according to their BMI had almost 5 times the amount of missed works days as a result of injury in comparison to those of normal weight.

Researchers calculated the costs of firefighter absenteeism due to non-fatal injury and concluded costs escalated from $74.41 per firefighter deemed overweight to $1682.90 classified as class II and III obese per year. Mean BMI of City 1 and City 2 candidates in our study approached significance (p=0.07) and a greater percentage of City 2 applicants were found to be in the combined overweight/obese categories. If we consider the reported expense by Posten et al. (2011b) relative to the BMI values for our City 2 candidates, we calculate a conservative estimate of $7359.82 associated with injury related to absenteeism over one year. However, it is important to note these costs do not account for additional factors contributing to lost work. Furthermore, as weight gain is found to increase in firefighters over their career, it is expected these costs are associated with their first year of service and would continue to escalate over time. Therefore, hiring a greater portion of firefighters classified as normal weight would decrease the financial burden to the fire service as projected in City 1 applicants.

Our study also found the sum of z-scores to be significantly different between cities as a result of City 1 performing better on the majority of all clinical health and fitness and occupational assessments. As the performance of firefighting tasks is identified to be correlated with each component of fitness, (Michaelides et al., 2008, 2011; Rhea et al., 2004; Sheaff et al., 2010; Williford et al., 1999; Williams-Bell et al., 2009) job performance of City 1 applicants may be more efficient.

A significant difference in trunk flexibility z-scores was specifically found between the cities. While the utility of flexibility in the fire service is not as frequently reported in the literature, some evidence suggests improved firefighting performance exists with regard to occupational duties (Michaelides et al., 2008; Williford et al., 1999). Furthermore, a reduced number of lower extremity overuse injuries were found with increased hamstring flexibility in military trainees (Hartig & Henderson, 1999). Similarly, Hilyer and colleagues (1990) reported a decrease in severity of injuries found in firefighters and related costs to the fire service with improved flexibility following an exercise intervention (Hilyer et al., 1990). While we observed enhanced flexibility in our City 1 firefighters, we did not report occupational related injuries and therefore are not able to support the findings outlined above. Further research is warranted on the importance of flexibility in firefighters.

5.2 Hiring process of firefighters

Our findings suggest City 1's hiring sequence incorporating biophysical assessments at the beginning of the selection process results in hiring a healthier firefighter as demonstrated by significantly lower relative body fat, higher absolute body fat and trunk flexibility z-scores and sum of z-scores. It is also important to note that the City 1 hiring sequence may have additional benefits such as saved time and resources to the department. City 2's process involves a complexity of multiple steps such as written aptitude and knowledge tests, application review, and finally an applicant interview prior to the conditional offer of employment, and all of these steps are still pending the candidate's ability to pass a biophysical assessment. As a result, time and resources are wasted by the City 2 fire service by conducting each step of the hiring process in advance of knowing a candidate's overall health and occupational ability. Therefore, City 2 will be required to restart the hiring process if the applicant does not pass the biophysical assessments.

Brownlie and colleagues (1985) support the findings of our study whereby their sequence in the selection process for entry level firefighters reflected that of our study. They were also able to demonstrate a cost savings associated with executing a screening sequence using biophysical assessment components comparable to City 1. They found initial pre-screening weighed primarily on physical capabilities to effectively narrow the applicant pool to a viable group of firefighter candidates. Furthermore, they credited a significant cost savings over four years by utilizing a biophysical pre-screening approach as well as reduced time in training and physical conditioning of these new probationary firefighters. As a result, fire service personnel were afforded more time to invest in advanced firefighting training suppression techniques for their new recruits (Brownlie et al., 1985).

Although our study reported that City 1 applicants demonstrated a healthier biophysical profile, it is challenging to speculate exactly why physical screening implemented early in the hiring process appears to be a preferred approach as this was not the intent of this study. Nevertheless, we conjecture that City 1 applicants may demonstrate more favourable health profiles as applicants are required to successfully pass all BUFF testing components prior to applying to the human resource department for City 1, which is in contrast to that of City 2. Therefore, it would suggest that City 1 appears to emphasize more so the physical capabilities of candidates due to the placement of the biophysical assessment early in the hiring algorithm. As a result, applicants are likely to ensure they exhibit a more optimal health profile in order to continue in the hiring process. Conversely, City 2 applicants may invest more so in preparing for the written and interview components as these are the primary assessment requirements for this fire service.

Furthermore, since City 1 applicants are completing the biophysical assessment at the beginning of the hiring sequence, the applicant pool is considerably larger and physically competitive compared to City 2 applicants. The greater amount of competition for minimal positions may also result in City 1 candidates ensuring optimal physical performance compared to City 2 applicants who have already received a conditional offer of employment at this stage of the screening process. City 2 applicants merely need to pass the biophysical testing to secure their employment and therefore their biophysical assessment scores are not subject to specific scrutiny by a corporation's human resource department. Brownlie et al. (1985) identified new recruits selected from their competitive hiring procedure felt an elite status as a result of their success through strongly emphasized biophysical screening, as well as increased confidence in their abilities to perform occupational duties compared to hires not participating in the new assessments. These intrinsic qualities are more likely to be demonstrated with the hiring approach implemented by City 1 fire service and are important in the maintenance of biophysical characteristics and setting a positive example for other members in the department (Brownlie et al., 1985). Finally, as City 2 requires the completion of multiple steps in the hiring process prior to biophysical assessments, the duration of time between the initial and final phases of employee selection, which can take several months, may result in the detraining of candidates.

Overall, it is recommended that the hiring process within an organization be viewed as a good investment by reducing employee turnover and maintaining a high level of productivity. Failure to screen out individuals can result in the hiring of an employee who does not demonstrate the required physical ability in both short and long term (Ahmad & Schroeder, 2002). Subsequently, this individual potentially increases the risk of injury, short and long term disability and the related compensation expenses associated with both human and economic costs (Brownlie et al., 1985). The overall financial burden of hiring the wrong employee from a biophysical standpoint is found to be greater than the implementation of a systematic and comprehensive selection practice (Garcia & Kleiner, 2001). Furthermore, a firefighter who is neither healthy nor physically capable can place co-workers and the public at risk while performing their duties. Therefore, a hiring sequence whereby biophysical and occupational assessment components are assessed at the beginning of the screening process could avoid candidates beginning their career demonstrating poorer health, which may potentially lead to increased health risk progressively over the course of their career.

5.3 Limitations and recommendations

This study has a number of limitations requiring discussion. First, only male subjects were examined due to the limited number of females hired in City 1 and City 2 between 2008 and 2012. Therefore, it is important to note the findings of this study are only relevant to the male gender and further investigation should include the female population that is progressively increasing. Additionally, only two large city fire services were analysed for the purpose of this study. Future research should examine if similar results are demonstrated in smaller fire service departments as well as volunteer fire departments.

Finally, the data available for this study was limited to the BUFF dataset, which was designed predominantly for assessing biophysical and occupational variables for hiring purposes in the fire service and not specifically for research purposes. As a result, other variables typically considered in the hiring process were not part of this database. Finally, future research should examine how biophysical and occupational measures from different hiring sequences impact work-related factors such as absenteeism rates, work related injuries or long-term physical and psychological health. Furthermore, the relationship of biophysical components to number of lives saved by firefighters is also an area to be considered (Brownlie et al., 1985). This information would provide support for the importance of hiring sequence on long-term outcomes of firefighter recruits.

5.4 Conclusions and Implications

The results of this study demonstrate that a corporate human resource department's hiring procedures that places the biophysical assessment at the end of the screening process may negatively impact the type of firefighter candidate selected by selecting weaker applicants in relation to clinical health status. As a result, the implementation of clinical health and occupational assessments at the beginning of the hiring process reveals a more favourable firefighter candidate in relation to the execution of the rigours of this physically demanding vocation. Furthermore, it is advantageous for applicants to exhibit optimal health prior to being hired to minimize the effects of aging on biophysical outcomes that a firefighter will experience over length of their career. Hiring candidates to begin their career with a preferable biophysical profile will result in both short and long term benefits when considering the health and performance requirements in the physically demanding occupation of a firefighter.

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APPENDICES

APPENDIX 1 – REB Letter of Approval

Brock University
Research Ethics Office
Tel: 905-688-5550 ext. 3035
Email: reb@brocku.ca

Bioscience Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

DATE:	1/3/2013		
PRINCIPAL INVESTIGATOR:	FAUGHT, Brent - Community Health Sciences		
FILE:	12-158 - FAUGHT		
TYPE:	Masters Thesis/Project	STUDENT: SUPERVISOR:	Carrie Schachtschneider Brent Faught

TITLE: Do hiring practices influence biophysical components in probationary firefighters?

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW Expiry Date: 1/31/2014

The Brock University Bioscience Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 1/3/2013 to 1/31/2014.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 1/31/2014. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Brian Roy, Chair
Bioscience Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.

APPENDIX 2 – Physical Activity Readiness Questionnaire

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of <u>any other reason</u> why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

<u>Informed Use of the PAR-Q</u>: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ______________________________

SIGNATURE ______________________________ DATE ______________________________

SIGNATURE OF PARENT ______________________________ WITNESS ______________________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Supported by: Health Canada Santé Canada

continued on other side...

APPENDIX 3 – PARMED-X

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP Certified Exercise Physiologist®. To assist in this, the following instructions are provided:

PAGE 1: • Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGES 2 & 3: • A checklist of medical conditions requiring special consideration and management.

PAGE 4: • Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.

• Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION:

NAME ______________________

ADDRESS ______________________

____

TELEPHONE ______________________

BIRTHDATE ______________________ GENDER __________

MEDICAL No. ______________________

B PAR-Q: Please indicate the PAR-Q questions to which you answered YES

- ❑ Q 1 Heart condition
- ❑ Q 2 Chest pain during activity
- ❑ Q 3 Chest pain at rest
- ❑ Q 4 Loss of balance, dizziness
- ❑ Q 5 Bone or joint problem
- ❑ Q 6 Blood pressure or heart drugs
- ❑ Q 7 Other reason: ______________________

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:

Check all that apply

- ❑ Less than 30 minutes of moderate physical activity most days of the week.
- ❑ Currently smoker (tobacco smoking 1 or more times per week).
- ❑ High blood pressure reported by physician after repeated measurements.
- ❑ High cholesterol level reported by physician.
- ❑ Excessive accumulation of fat around waist.
- ❑ Family history of heart disease.

***Please note:** Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.*

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

____

____

____

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

- ❑ Cardiovascular
- ❑ Respiratory
- ❑ Other
- ❑ Musculoskeletal
- ❑ Abdominal

Tests required:

- ❑ ECG
- ❑ Exercise Test
- ❑ X-Ray
- ❑ Blood
- ❑ Urinalysis
- ❑ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommend:

Further Information:
- ❑ Attached
- ❑ To be forwarded
- ❑ Available on request

- ❑ No physical activity
- ❑ Only a medically-supervised exercise program until further medical clearance
- ❑ Progressive physical activity:
  - ❑ with avoidance of: ______________________
  - ❑ with inclusion of: ______________________
  - ❑ under the supervision of a CSEP Certified Exercise Physiologist®
- ❑ Unrestricted physical activity–start slowly and build up gradually

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

Following is a checklist of medical conditions for which a degree of precaution and/or special advice should be considered for those who answered "YES" to one or more questions on the PAR-Q, and people over the age of 69. Conditions are grouped by system. Three categories of precautions are provided. Comments under Advice are general, since details and alternatives require clinical judgement in each individual instance.

	Absolute Contraindications	Relative Contraindications	Special Prescriptive Conditions	ADVICE
	Permanent restriction or temporary restriction until condition is treated, stable, and/or past acute phase.	Highly variable. Value of exercise testing and/or program may exceed risk. Activity may be restricted. Desirable to maximize control of condition. Direct or indirect medical supervision of exercise program may be desirable.	Individualized prescriptive advice generally appropriate: • limitations imposed; and/or • special exercises prescribed. May require medical monitoring and/or initial supervision in exercise program.	
Cardiovascular	❑ aortic aneurysm (dissecting) ❑ aortic stenosis (severe) ❑ congestive heart failure ❑ crescendo angina ❑ myocardial infarction (acute) ❑ myocarditis (active or recent) ❑ pulmonary or systemic embolism—acute ❑ thrombophlebitis ❑ ventricular tachycardia and other dangerous dysrhythmias (e.g., multi-focal ventricular activity)	❑ aortic stenosis (moderate) ❑ subaortic stenosis (severe) ❑ marked cardiac enlargement ❑ supraventricular dysrhythmias (uncontrolled or high rate) ❑ ventricular ectopic activity (repetitive or frequent) ❑ ventricular aneurysm ❑ hypertension—untreated or uncontrolled severe (systemic or pulmonary) ❑ hypertrophic cardiomyopathy ❑ compensated congestive heart failure	❑ aortic (or pulmonary) stenosis—mild angina pectoris and other manifestations of coronary insufficiency (e.g., post-acute infarct) ❑ cyanotic heart disease ❑ shunts (intermittent or fixed) ❑ conduction disturbances • complete AV block • left BBB • Wolff-Parkinson-White syndrome ❑ dysrhythmias—controlled ❑ fixed rate pacemakers	• clinical exercise test may be warranted in selected cases, for specific determination of functional capacity and limitations and precautions (if any). • slow progression of exercise to levels based on test performance and individual tolerance. • consider individual need for initial conditioning program under medical supervision (indirect or direct).
			❑ intermittent claudication	progressive exercise to tolerance
			❑ hypertension: systolic 160-180; diastolic 105+	progressive exercise; care with medications (serum electrolytes; post-exercise syncope; etc.)
Infections	❑ acute infectious disease (regardless of etiology)	❑ subacute/chronic/recurrent infectious diseases (e.g., malaria, others)	❑ chronic infections ❑ HIV	variable as to condition
Metabolic		❑ uncontrolled metabolic disorders (diabetes mellitus, thyrotoxicosis, myxedema)	❑ renal, hepatic & other metabolic insufficiency	variable as to status
			❑ obesity ❑ single kidney	dietary moderation, and initial light exercises with slow progression (walking, swimming, cycling)
Pregnancy		❑ complicated pregnancy (e.g., toxemia, hemorrhage, incompetent cervix, etc.)	❑ advanced pregnancy (late 3rd trimester)	refer to the "PARmed-X for PREGNANCY"

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. **J. Clin. Epidemiol.** 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health**. Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17: 4 338-345.

The PAR-Q and PARmed-X were developed by the British Columbia Ministry of Health. They have been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Évaluation médicale de l'aptitude à l'activité physique (X-AAP)»

Continued on page 3...

	Special Prescriptive Conditions	ADVICE
Lung	❑ chronic pulmonary disorders	special relaxation and breathing exercises
	❑ obstructive lung disease ❑ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	❑ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	❑ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	❑ arthritis—acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	❑ arthritis—subacute	progressive increase of active exercise therapy
	❑ arthritis—chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	❑ orthopaedic	highly variable and individualized
	❑ hernia	minimize straining and isometrics; stregthen abdominal muscles
	❑ osteoporosis or low bone density	avoid exercise with high risk for fracture such as push-ups, curl-ups, vertical jump and trunk forward flexion; engage in low-impact weight-bearing activities and resistance training
CNS	❑ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountainclimbing, etc.)
	❑ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness, retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	❑ anemia—severe (< 10 Gm/dl) ❑ electrolyte disturbances	control preferred; exercise as tolerated
Medications	❑ antianginal ❑ antiarrhythmic ❑ antihypertensive ❑ anticonvulsant ❑ beta-blockers ❑ digitalis preparations ❑ diuretics ❑ ganglionic blockers ❑ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	❑ post-exercise syncope	moderate program
	❑ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	❑ temporary minor illness	postpone until recovered
	❑ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights.

*Refer to special publications for elaboration as required

The following companion forms are available online: www.csep.ca/publications

The **Physical Activity Readiness Questionnaire (PAR-Q)** - a questionnaire for people aged 15-69 to complete before becoming much more physically active. Please return the completed form to the participant or his/her physical activity professional.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY)** - to be used by physicians with pregnant patients who wish to become more physically active. Please return the completed form to the participant or his/her physical activity professional.

For more information, please contact the:

Canadian Society for Exercise Physiology
370-18 Louisa Street
Ottawa, Ontario K1R 6Y6
Tel. 1-877-651-3755 • Online: www.csep.ca

Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

Continued on page 4...

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

CANADA'S Physical Activity Guide to Healthy Active Living

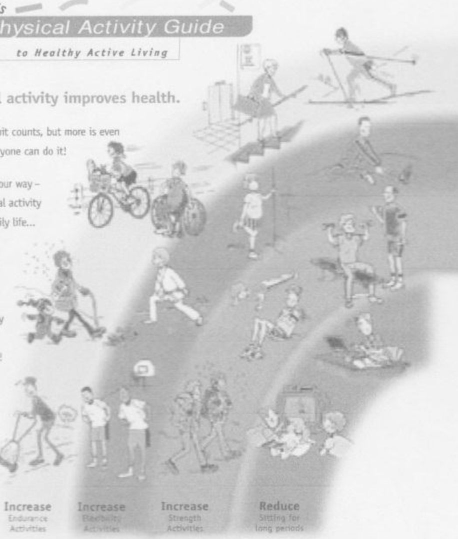
Physical activity improves health.

Every little bit counts, but more is even better – everyone can do it!

Get active your way – build physical activity into your daily life...

* at home
* at school
* at work
* at play
* on the way

...that's active living!



Choose a variety of activities from these three groups:

Endurance
4-7 days a week
Continuous activities for your heart, lungs and circulatory system.

Flexibility
4-7 days a week
Gentle reaching, bending and stretching activities to keep your muscles relaxed and joints mobile.

Strength
2-4 days a week
Activities against resistance to strengthen muscles and bones and improve posture.

Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the *Guide Handbook* and more information: **1-888-334-9769**, or **www.paguide.com**

Eating well is also important. Follow *Canada's Food Guide to Healthy Eating* to make wise food choices.

Get Active Your Way, Every Day – For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort

Very Light Effort	Light Effort *60 minutes*	Moderate Effort *30-60 minutes*	Vigorous Effort *20-30 minutes*	Maximum Effort
• Strolling • Dusting	• Light walking • Volleyball • Easy gardening • Stretching	• Brisk walking • Biking • Raking leaves • Swimming • Dancing • Water aerobics	• Aerobics • Jogging • Hockey • Basketball • Fast swimming • Fast dancing	• Sprinting • Racing

Range needed to stay healthy

You Can Do It – Getting started is easier than you think

Physical activity doesn t have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can – get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk – gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start – you don t have to make a long-term commitment.
- Do the activities you are doing now, more often.

Benefits of regular activity:

- better health
- improved fitness
- better posture and balance
- better self-esteem
- weight control
- stronger muscles and bones
- feeling more energetic
- relaxation and reduced stress
- continued independent living in later life

Health risks of inactivity:

- premature death
- heart disease
- obesity
- high blood pressure
- adult-onset diabetes
- osteoporosis
- stroke
- depression
- colon cancer

Health Canada Santé Canada
Canadian Society for Exercise Physiology

Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

PARmed-X Physical Activity Readiness Conveyance/Referral Form

Based upon a current review of the health status of ______________________________, I recommend:

- ❑ No physical activity
- ❑ Only a medically-supervised exercise program until further medical clearance
- ❑ Progressive physical activity
  - ❑ with avoidance of: ______________________________
  - ❑ with inclusion of: ______________________________
  - ❑ under the supervision of a CSEP Certified Exercise Physiologist®
- ❑ Unrestricted physical activity — start slowly and build up gradually

Further Information:
- ❑ Attached
- ❑ To be forwarded
- ❑ Available on request

Physician/clinic stamp:

______________________________ M.D.

______________________________ 20______
(date)

NOTE: This physical activity clearance is valid for a maximum of six months from the date it is completed and becomes invalid if your medical condition becomes worse.

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APPENDIX 4 – Informed Consent

Brock

Assumption of Risk and Release of Liability Form
Firefighter Screening Services

First Name (please print):	Last Name (please print):	Date of Birth: ___ ___ / ___ ___ / ___ ___ ___ ___ (mm) (dd) (yyyy)

OPTIONAL: Please check below any of the following groups you wish to be self-identified with. This will be forwarded to municipalities requesting this information.

( ) **Women**

( ) **First Nations** - Aboriginal peoples are those who identify themselves as Indian (Status or Non-Status), Inuit, or Métis.

( ) **Visible Minority** - Members of visible minority groups are people, other than aboriginal people, who are, because of their race or colour, in a visible minority in Canada and who identify themselves as non-Caucasian in race or non-white in colour. *Please note this is not based on nationality, citizenship, religion, or ethnicity.* You may identify yourself with a visible minority group whether or not you are born in Canada or are a Canadian citizen. Groups such as Polish, Italian, Greek, etc., would not be considered visible minorities.

Please read the following information carefully.

Description of Risks

In order to assess a firefighter applicant's physical fitness, occupational skill and psychological aptitude, the undersigned must complete the following tests: a clinical assessment, an occupational assessment and an aptitude assessment (the "Tests"). By signing this document you indicate that you fully understand the risks involved with the Tests and agree to assume such risks. Further, you agree to waive certain legal rights that you may have against Brock University should you suffer any damages to yourself or your personal property, or cause any damage to a third party, during the administration of the Tests. I am aware that by participating in the Tests that I will be exposed to the following inherent risks, including but not limited to: injuries from vigorous physical exertion and strenuous cardiovascular output; injuries from demanding physical techniques and maneuvers; injuries from falling and impacting against the floor, stairs or equipment; injuries from collisions with walls, low ceilings and equipment. Further, I am aware: that injuries sustained during the Tests may be severe; that the risk of injury increases as I become fatigued; that it is my responsibility to ensure I am physically and psychologically fit to participate in the Tests.

Assumption of Risk and Release of Liability

I hereby agree to assume all risks arising out of, associated with or relating to my participation in the Tests. I agree to be solely responsible for any injury, loss or damage that may be sustained during my participation in the Tests. In particular, I agree that if Brock University, in its sole discretion and on my behalf, should secure any medical advice or services as it may deem necessary for my health and safety, that I shall be financially responsible for such medical advice or services. I hereby agree to WAIVE any and all claims that I have or may have against Brock University, its Board of Trustees, officers, employees, students, agents, volunteers, and independent contractors (the "Brock Parties"). I further agree to release the Brock Parties from any and all liability for any loss, damage, injury or expense that I may suffer, or that my next of kin may suffer as a result of my participation in the Tests, due to any cause whatsoever INCLUDING NEGLIGENCE, BREACH OF CONTRACT OR BREACH OF ANY DUTY OF CARE owed on the part of the Brock Parties. I further agree to INDEMNIFY AND HOLD HARMLESS the Brock Parties from any and all liability for any damage to the property of, or personal injury to, any third party, resulting from my participation in the Tests.

Acknowledgement

I HAVE READ AND UNDERSTOOD THIS AGREEMENT. I AM AWARE THAT BY SIGNING THIS AGREEMENT I AM WAIVING CERTAIN LEGAL RIGHTS WHICH I, OR MY NEXT OF KIN, MAY HAVE AGAINST THE BROCK PARTIES.

Signed this ____________ day of ______________________, 201___ at St. Catharines, Ontario.
(day) (month) (yr)

____

Signature of Participant (I am 18 years of age or older)

Brock University protects your privacy and your personal information. The personal information requested is collected under the authority of The Brock University Act, 1964, and in accordance with the Freedom of Information and Protection of Privacy Act (FIPPA) for the purpose of screening and collecting applications from firefighter candidates. Date of birth is required to determine age- based clinical scores. Test results and application materials will be forwarded to the municipalities you identified upon registration. Direct any questions about this collection to the Manager of Brock University Firefighter Screening Services at firefighter@brocku.ca or (905) 688 – 5550 ext. 5070.

For office use only:

______________________________ ______________________________

Witness Name (please print) **Witness Signature**

APPENDIX 5 – Normative Data

BROCK UNIVERSITY FIREFIGHTER SCREENING SERVICES
- NORMATIVE DATA -

BODY COMPOSITION (Total 5 Points)

Classification (%)	*Male (15-49)*	*Female (15-49)*
Excellent (5 points)	≤ 10	≤ 15
Above Average (4 points)	11 - 14	16 - 19
Average (3 points)	15 - 17	20 - 24
Below Average (2 points)	18 - 19	25 - 29
Poor (1 point)	≥ 20	≥ 30
Failure to participate (0 points)	---------	---------

WAIST TO HIP RATIO (Total 5 Points)

Classification	*Male (20-29)*	*Male (30-39)*	*Male (40-49)*	*Male (50-59)*
Excellent (5 points)	≤ 0.8	≤ 0.81	≤ 0.85	≤ 0.86
Above Average (4 points)	$0.8 < x \geq 0.83$	$0.81 < x \geq 0.84$	$0.85 < x \geq 0.88$	$0.87 < x \geq 0.9$
Average (3 points)	$0.83 < x \geq 0.88$	$0.84 < x \geq 0.91$	$0.88 < x \geq 0.95$	$0.90 < x \geq 0.96$
Below Average (2 points)	$0.88 < x \geq 0.94$	$0.91 < x \geq 0.96$	$0.95 < x \geq 1.0$	$0.96 < x \geq 1.02$
Poor (1 point)	> 0.94	> 0.96	> 1.00	> 1.02
Failure to participate (0 points)	---------	---------	---------	---------

Classification	*Female (20-29)*	*Female (30-39)*	*Female (40-49)*	*Female (50-59)*
Excellent (5 points)	≤ 0.67	≤ 0.68	≤ 0.69	≤ 0.7
Above Average (4 points)	$0.68 < x \geq 0.71$	$0.69 < x \geq 0.72$	$0.70 < x \geq 0.73$	$0.71 < x \geq 0.74$
Average (3 points)	$0.71 < x \geq 0.77$	$0.72 < x \geq 0.78$	$0.74 < x \geq 0.79$	$0.74 < x \geq 0.79$
Below Average (2 points)	$0.77 < x \geq 0.82$	$0.78 < x \geq 0.84$	$0.79 < x \geq 0.87$	$0.79 < x \geq 0.88$
Poor (1 point)	≥ 0.82	≥ 0.84	≥ 0.87	> 0.88
Failure to participate (0 points)	---------	---------	---------	---------

TRUNK FLEXION (Total 5 Points)

Classification (cm)	*Male (15-19)*	*Male (20-29)*	*Male (30-39)*	*Male (40-49)*
Excellent (5 points)	≥ 39	≥ 40	≥ 38	≥ 35
Above Average (4 points)	34 - 38	34 - 39	33 - 37	29 - 34
Average (3 points)	29 - 33	30 - 33	28 - 32	24 - 28
Below Average (2 points)	24 - 28	25 - 29	23 - 27	18 - 23
Poor (1 point)	≤ 23	≤ 24	≤ 22	≤ 17
Failure to participate (0 points)	---------	---------	---------	---------

Classification (cm)	*Female (15-19)*	*Female (20-29)*	*Female (30-39)*	*Female (40-49)*
Excellent (5 points)	≥ 43	≥ 41	≥ 41	≥ 38
Above Average (4 points)	38 - 42	37 - 40	36 - 40	34 - 37
Average (3 points)	34 - 37	33 - 36	32 - 35	30 - 33
Below Average (2 points)	29 - 33	28 - 32	27 - 31	25 - 29
Poor (1 point)	≤ 28	≤ 27	≤ 26	≤ 24
Failure to participate (0 points)	---------	---------	---------	---------

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BROCK UNIVERSITY FIREFIGHTER SCREENING SERVICES
- NORMATIVE DATA -

60-SECOND SIT-UPS (Total 5 Points)

Classification (cm)	*Male (15-19)*	*Male (20-29)*	*Male (30-39)*	*Male (40-49)*
Excellent (5 points)	≥ 62	≥ 55	≥ 51	≥ 47
Above Average (4 points)	51 - 61	47 - 54	43 - 50	39 - 46
Average (3 points)	47 - 50	42 - 46	39 - 42	34 - 38
Below Average (2 points)	41 - 46	38 - 41	35 - 38	29 - 33
Poor (1 point)	≤ 40	≤ 37	≤ 34	≤ 28
Failure to participate (0 points)	---------	---------	---------	---------

Classification (cm)	*Female (15-19)*	*Female (20-29)*	*Female (30-39)*	*Female (40-49)*
Excellent (5 points)	≥ 55	≥ 51	≥ 42	≥ 38
Above Average (4 points)	46 - 54	44 - 50	35 - 41	29 - 37
Average (3 points)	36 - 45	38 - 43	29 - 34	24 - 28
Below Average (2 points)	32 - 35	32 - 37	25 - 28	20 - 23
Poor (1 point)	≤ 31	≤ 31	≤ 24	≤ 19
Failure to participate (0 points)	---------	---------	---------	---------

MAXIMUM AEROBIC FITNESS (Total 10 Points)

Classification (ml/kg/min)	*Female (20-29)*	*Female (30-39)*	*Female (40-49)*	*Female (50-59)*
Excellent (10 points)	≥ 47	≥ 46	≥ 44	≥ 41
Above Average (7 points)	41 - 46	39 - 45	38 - 43	35 - 40
Average (5 points)	35 - 40	34 - 38	32 - 37	29 -34
Below Average (3 points)	29 - 34	28 - 33	26 - 31	22 - 28
Poor (1 point)	≤ 28	≤ 27	≤ 25	≤ 21
Failure to participate (0 points)	---------	---------	---------	---------

MAXIMUM AEROBIC FITNESS (Total 10 Points)

Classification (ml/kg/min)	*Male (20-29)*	*Male (30-39)*	*Male (40-49)*	*Male (50-59)*
Excellent (10 points)	≥ 56	≥ 51	≥ 47	≥ 43
Above Average (7 points)	51 - 55	43 - 50	41 - 46	39 - 42
Average (5 points)	42 - 50	38 - 42	36 - 40	31 - 38
Below Average (3 points)	38 - 41	34 - 37	30 - 35	26 - 30
Poor (1 point)	≤ 37	≤ 33	≤ 29	≤ 25
Failure to participate (0 points)	---------	---------	---------	---------